AFAPL-TR-76-43 VOLUME VII

AIRCRAFT HYDRAULIC SYSTEMS DYNAMIC ANALYSIS

VOLUME VII
TRANSIENT THERMAL ANALYSIS (HYTTHA)
COMPUTER PROGRAM USER MANUAL

MCDONNELL AIRCRAFT COMPANY
MCDONNELL DOUGLAS CORPORATION
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AIR FORCE AERO PROPULSION LABORATORY
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

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Neil Pierce and Gerry Amies of McDonnell Douglas Corporation were technically responsible for the work.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Hydraulic Transient Thermal Analysis (HYTTHA) computer program has been developed to predict temperatures, and temperature gradients in hydraulic components and systems, due to changes in flow demands.

The steady state flows and pressures throughout the system are used by the thermal portion of the program to predict fluid temperatures, line wall temperatures, component temperatures, and other component variables.

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The engineering input data to the program is normally available to a design engineer. Additional components, not covered here, may be added if necessary without much effort.

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1.0 INTRODUCTION

The Hydraulic Transient Thermal Analysis (HYTTHA) computer program is intended for use by designers with an interest in the thermal effects on the performance of an aircraft hydraulic system.

An aircraft hydraulic system is basically a power source connected to several loads. Under steady state conditions, where only the pump and fluid are moving (the pump having internal moving parts), the flows and pressures at various points in the system can be calculated using non-time dependent formulas. These conditions are input for the evaluation of the temperatures throughout the system caused by interactions between the fluid and the components. The pump is the most common source of heat to the system. It supplies work and heat to the fluid. Other components change temperatures in the system by altering the pressure and flow.

The program simulates complete systems. It calculates values of flows, pressures, state variables, component temperatures, fluid temperatures, and line wall temperatures throughout the system.

The program is composed of five basic parts; input, steady state calculations, line calculations, component calculations, and output.

The designer inputs data describing the lines, components, and system configuration. Since the simulation is only as good as the data, some of the information required for components, such as a pump, is very detailed.

The steady state part of the program balances the pressures and flows in the system, and calculates values for all the system state variables. Once the initial values are established at zero time, the program starts by calculating temperatures at different junctions in the system for a small change in time.

All lines are divided into segments for the calculations. The length of each segment, when calculated, is equal to the fluid volume flow rate times the time step divided by the fluid cross sectional area. An integer number of segments are

used, and the program adjusts the line segment lengths accordingly. The time interval, DELT, and segment length, DELTAX, may be input by the user. These parameters must be chosen carefully because the finite difference backwards mode of calculation can cause instability and erroneous results if the time step is too large. If this occurs, either decrease DELT or increase DELTAX.

Line segment temperatures are calculated with its temperature from the previous time and the updated temperature of the upstream line segment temperature and old downstream line segment temperature. Line segment temperatures are calculated each time, in sequence, moving down the line with the flow. Component fluid and wall temperatures are calculated next, using updated temperatures from the upstream and downstream line segments as boundary conditions.

The program continues the calculations at DELT intervals, first calculating the lines' temperatures and then component temperatures.

The program selects the values that are to be used as output or to be plotted, at specified time steps. It is not considered necessary to plot every value calculated. After calculations are completed, the output is printed and plotted.

2.0 TECHNICAL SUMMARY

The HYTTHA program is intended for use by engineers with varying interests. Some will be concerned with the systems as a whole, while others will be interested in detailed information from individual components or sections of systems.

HYTTHA uses a building block approach. This approach allows the user to meet his needs by adding special component subroutines to the existing component subroutine library, if required.

The transient thermal analysis uses a finite difference formulation for the basic modes of heat transfer: convection, conduction, and radiation, plus mass flow transfer and pressure work. Several nodes are defined for the lines and components of a system. A node is a portion of a line or component of a specified volume. These nodes interact thermally with connecting nodes via the various modes of heat transfer defined above. At the end of each DELT, each fluid or wall (solid) node is at its own temperature. The heat balance for each node is defined in a finite difference format. Node temperatures are determined by integrating with available computer techniques.

The input to the analyses are initial temperatures and pressures, and flow disturbances which change temperatures in the system. The output of the analysis is a time history of pressures, flows, and temperatures at all nodes or connections in the system. Selected system variables, which have been changed by the controlling input, may be output as well.

This user's manual describes how the program can be used, the method of inputing the data, and the forms of the available outputs.

3.0 GENERAL DESCRIPTION

The program requires a detailed description of the system conditions, lines, components, the output data required and the system layout.

The system to be investigated must be carefully described in block diagram form before the data input cards can be produced. See Figure 3.0-1.

The lines are numbered sequentially and have designated upstream and downstream ends. For simplicity this should follow a reasonable sequence, through the system. One line number can be used to represent any number of lines in a series provided the diameter, wall thickness, and line type and material of each line are identical. A branch may be used to connect two lines of different diameters. The components which include line junctions or branches are then numbered as a separate sequence. Both sequences start at #1 and there should be no missing numbers.

Once the lines and components have been numbered, the next job is to assign numbers to points or nodes (not the same as line or component nodes) at which the flow divides or combines under steady state flow conditions.

The pump is usually assigned as node 1, since it is the flow source. If the system has two pumps, the second pump is node #2, and so on. Once the nodes are all numbered, the legs or flow paths between nodes are then numbered until all the flow paths between nodes are accounted for.

The system should now have numbers assigned to all the lines, components, nodes, and legs. Also, component connection numbers and leg flow direction should be used so that the proper line number and flow sign can be assigned to each specific component connection.

The preparation of the input data for each of these groups is described in the following paragraphs.

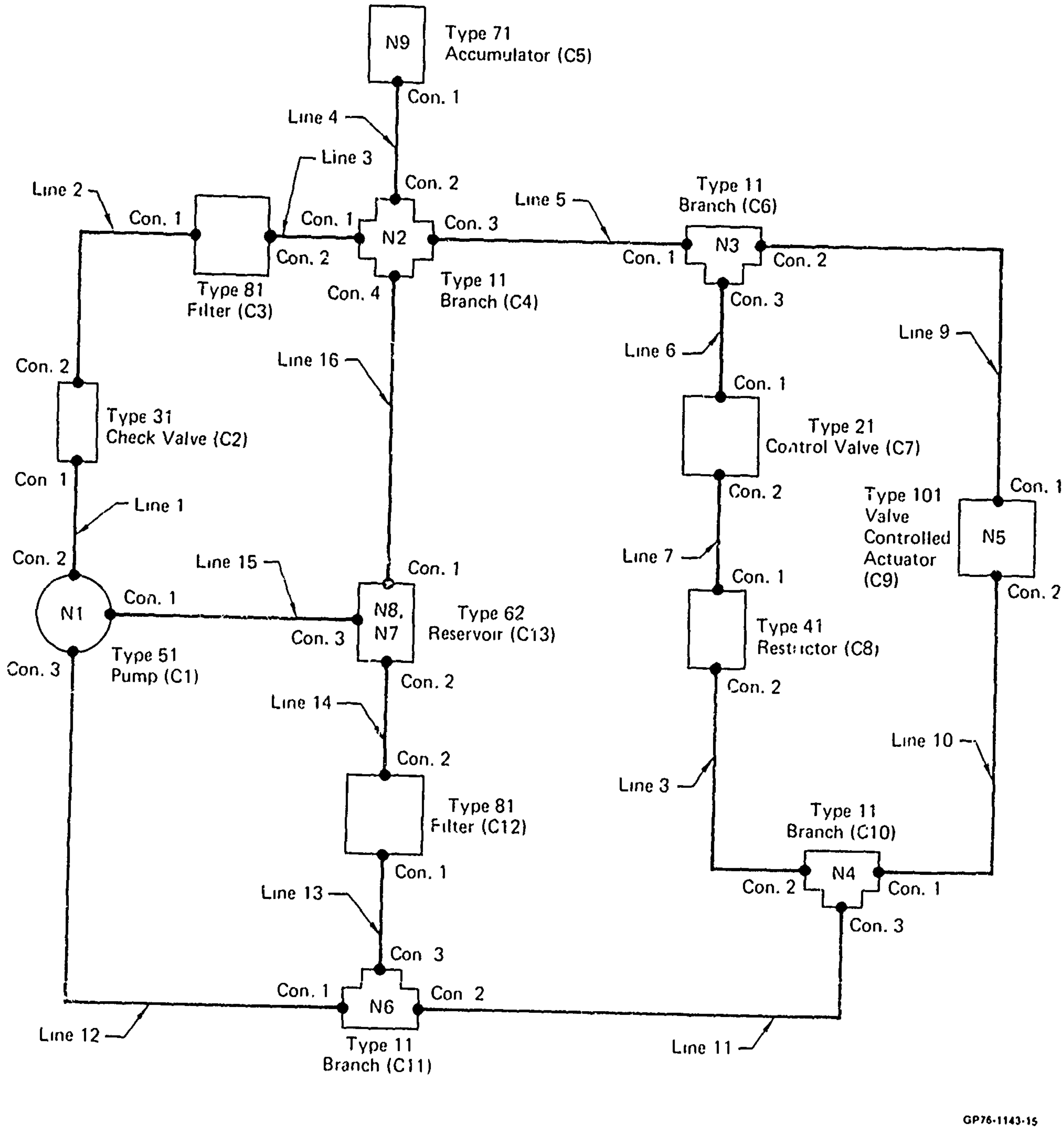


FIGURE 3.0-1
EXAMPLE SYSTEM

5.0 LINE DATA

6.0 COMPONENT DATA

7.0 SYSTEM ARRANGEMENT DATA

8.0 OUTPUT REQUIREMENT DATA

This data is needed for all system simulations and rules for the input should be followed carefully to avoid rejected runs.

It should be noted that the current maximum number of lines (MNLINE), components (MNEL), legs (MNLEG) nodes, (MNODE), plots (MNPLOT) and line points (MNLPTS) that can be input are established in Block Data. Hence Block Data must be changed if any of these maximums values are exceeded when inputting a system.

To have the subroutines select the correct properties, each subroutine has one or more inputs of material type. This material type is a number associated with a certain metal, listed below, and is to be used for each subroutine in the program.

MTYPE	MATERIAL	TYPE
1	Titanium	6AL-2SN-4ZR-2MO
2	Titanium	6AL-4V
3	Titanium	6AL-6V-2SN
4	Aluminum	2014
5	Aluminum	2024-T6
6	Aluminum	6061-T6
7	Aluminum	7075-T6
8	Steel	4130
9	Steel	301
10	Steel	304
11	Steel	17-4PH
12	Steel	A286
13	Teflon	--

Another input for each component is a D(PERC) term.

D(PERC) is used to evaluate how much of the heat, generated by a pressure drop, is added directly into the fluid. A value of 1.0 - D(PERC) of that heat is added into the walls in contact with the fluid. Normally D(PERC) equals 1.0.

Description of Figure 3.0-1

Figure 3.0-1 shows a simple hydraulic system utilizing lines and different types of components currently in the program. This system illustrates how lines, components, connections, legs and nodes are numbered. As an aid, the integer data shown on the following example data cards have been input to reflect this system where applicable.

1. Symbol Definition

Symbol	Description
NXX	Node number XX
CYY	Component number YY

2. Assignment of Leg Numbers

Once node points are established, leg numbers are set up to represent component(s) and or lines between nodes as follows.

Leg. No.	Leg Goes From
1	*N7 to N1
2	N1 to N6
3	N3 to N4
4	N3 to N5
5	N5 to N4
6	N4 to N6
7	N6 to N7*
8	N2 to N3
9	*N8 to N2
10	N2 to N9
11	N1 to N2

*Type 62 reservoir is unique in that its two nodes don't require a connecting leg.

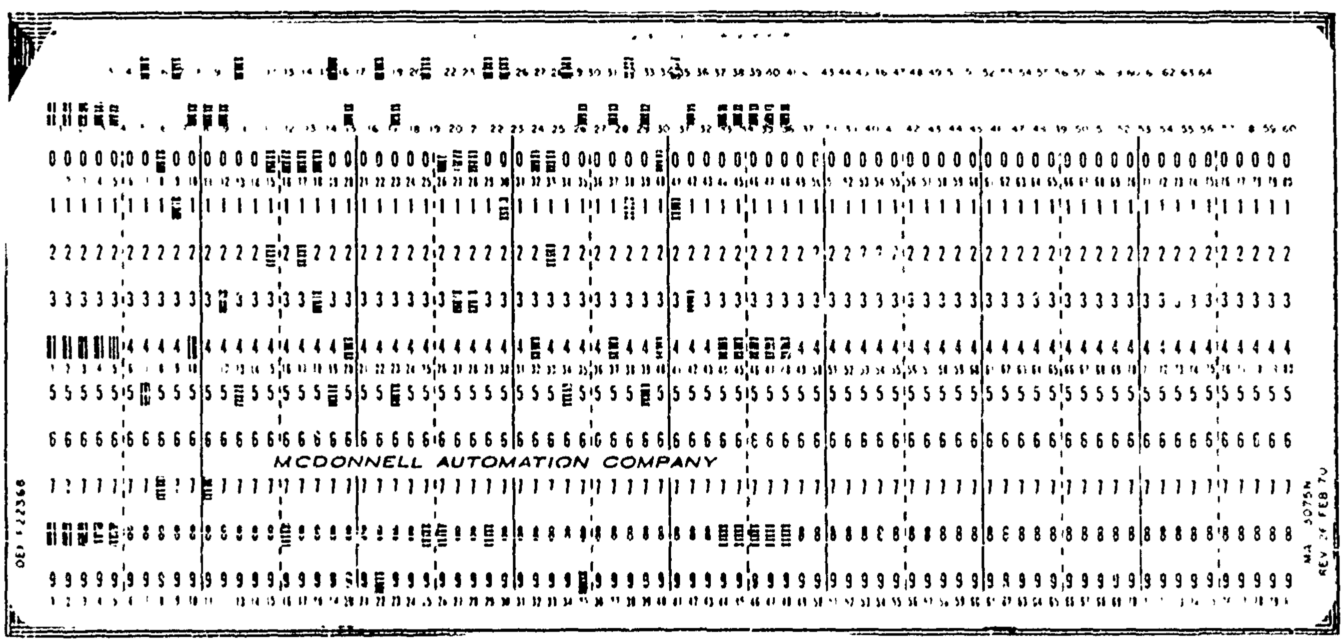
4.0 CONTROL DATA

4.1 GENERAL CONTROL DATA

This group includes three cards which set up the program title, time intervals, fluid temperature and type, number of lines and components and pressures.

Card 1 - This card inputs the program title. A maximum of 80 alphameric characters can be used in the title starting at card column 1.

Example Card:



Card 2 - This card inputs data for the number of lines and components, and three times. Time one is the calculation time interval used as the main program time step. The second time is the total calculation time until program stops, and time three is the plotting time interval.

The time step should not be so large as to let the fluid travel further than the segment length, DELTAX during that time. If the time is chosen too large, the line routine will recalculate the segment length.

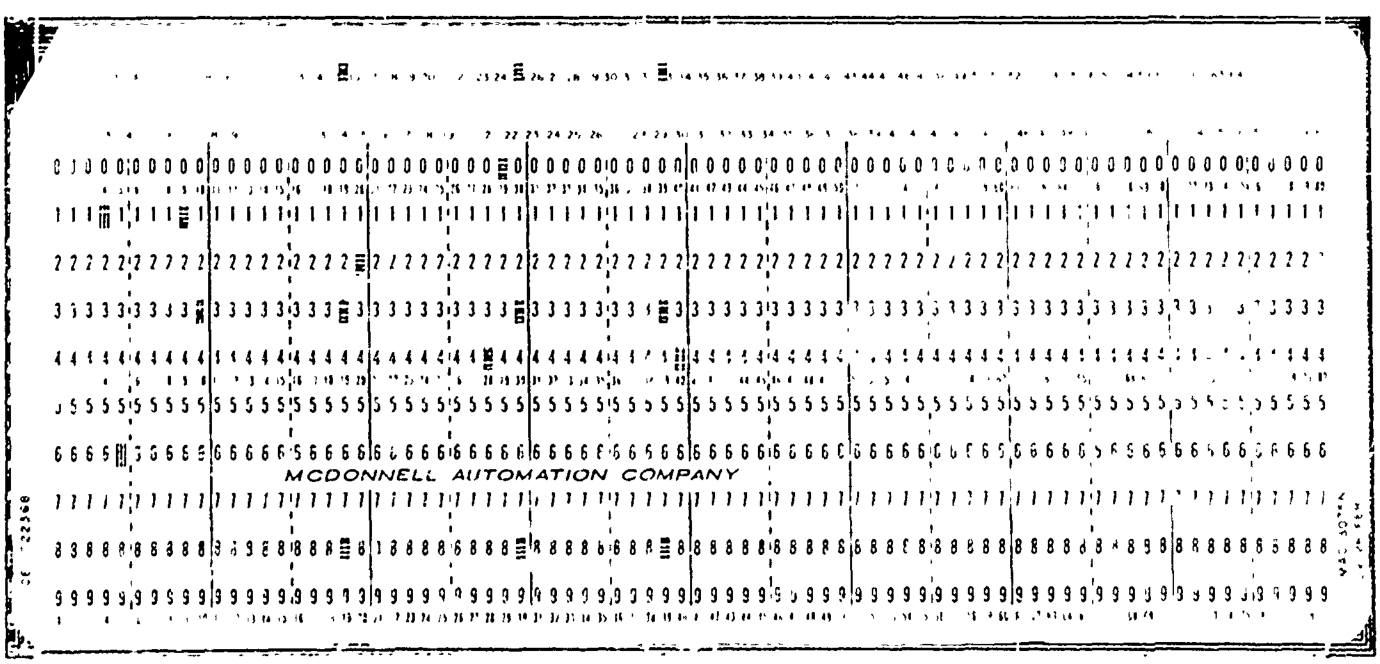
$$DELTAX = \frac{flow * time\ step}{fluid\ cross\ sectional\ area}$$

The plotting time interval is selected to suit the output device, the minimum being the calculation time interval. The actual value is usually chosen to give 101 plotted points (i.e. = final time $\div$ 100 or N times the calculation time interval so that every Nth calculated point is plotted).

CARD NUMBER 2

COLUMN	FORMAT	DATA	DIMENSIONS
1-5	I5	Total Number of Lines	—
6-10	I5	Total Number of Components	—
11-20	E10.0	Calculation Time Interval, DELT	SEC
21-30	E10.0	Final Time	SEC
31-40	E10.0	Plotting Time Interval	SEC

EXAMPLE CARD



Card 3 - The first value is the fluid type. The program is set up to run with either of the following fluid types at any temperature from -65°F to 300°F. If a computed temperature exceeds 300°F, the fluid properties at 300°F are used.

Type #1	MIL-H-5606B
Type #2	MIL-H-83282
Type #3	Skydrol 500B

The fluid type number selects the fluid data to be used from tabulated data stored in the program and adjusts the fluid properties to the computed pressure.

The second value is the fluid temperature throughout the system. This is intended as a default value should the user forget to enter the fluid temperature on the component cards. The fluid temperature will default to 100°F if this column is left blank.

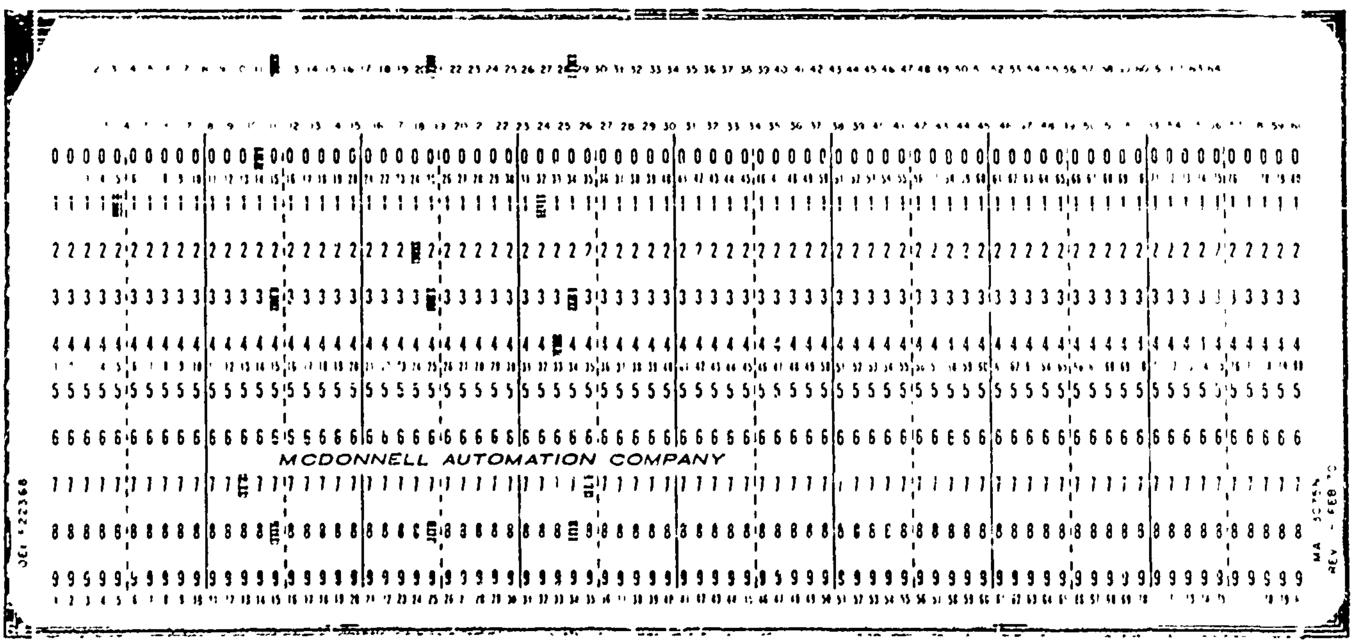
The third value is the fluid vapor pressure at the fluid temperature. Note: If the vapor pressure is not input the program will use a value of 2 psia.

The last value is the atmospheric pressure at the conditions of the run. The valve 14.7, atmospheric pressure at sea level will be used if this value is not input.

CARD NUMBER 3

COLUMN	FORMAT	DATA	DIMENSIONS
1-5	I5	Fluid Type Number	
6-15	E10.0	Fluid Temperature	°F
16-25	E10.0	Fluid Vapor Pressure	PSI
26-35	E10.0	Atmospheric Pressure	PSI

EXAMPLE CARD



5.0 LINE DATA

The number of cards used in this group will be twice the number of lines entered on card 2 (two cards for each line). An error message will be written when the number of lines exceeds the maximum number specified in block data and the program will stop. A line number may not be omitted or used twice.

To differentiate between rigid lines and flexible hoses the material type will be used. The same mathematical equations are involved with both types of lines so the same routine is used for each.

True bend angles less than 90° are summed and input in columns 31-35. Bend angles equal to or greater than 90° are summed and input in columns 36-40.

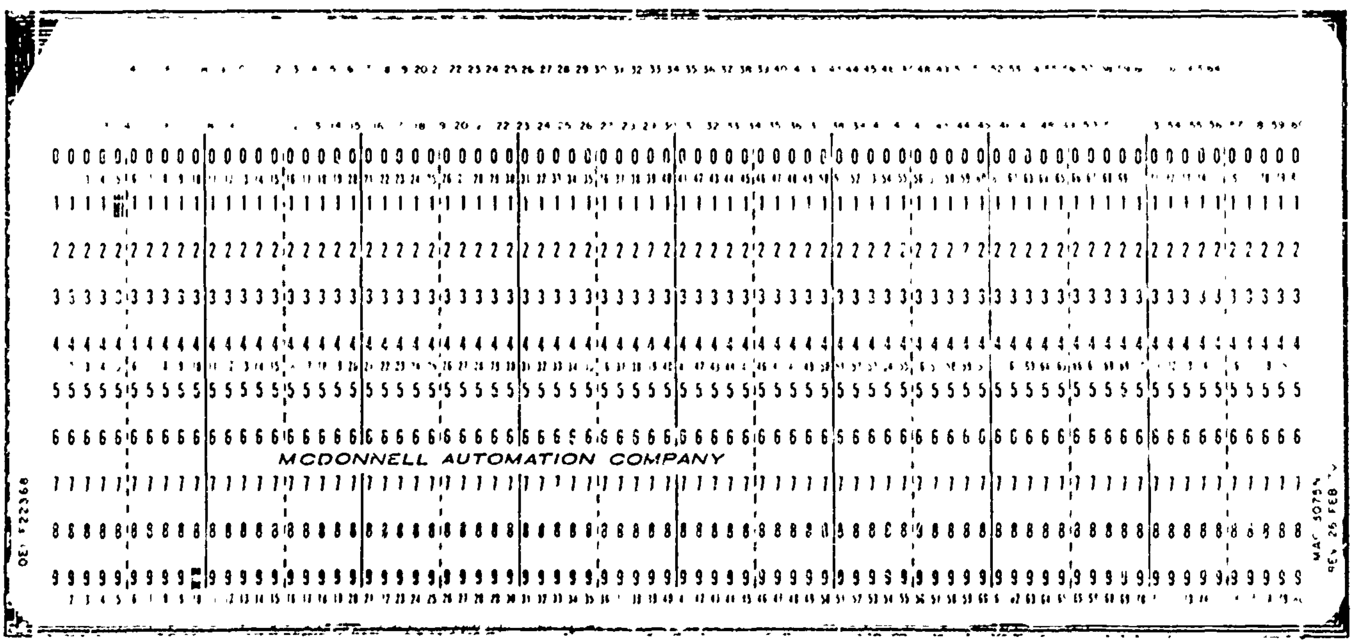
Card number two of the line data is self explanatory except for the heat transfer coefficient. If not input by user then the program will set it equal to 0.0069 which is a value nearly equal to that for still air.

TLINEA

CARD NUMBER 1

COLUMN	FORMAT	DATA	DIMENSIONS
1-5	I5	Line Number	--
6-10	I5	Material Type Number	--
11-15	I5	Percentage Increase in Line Friction	--
16-20	I5	Percentage Increase in Weight	--
21-25	I5	Number of 45° Elbows	--
26-30	I5	Number of 90° Elbows	--
31-35	I5	Total Bend Angles Less than 90°	DEG
36-40	I5	Total Bend Angles Greater than 90°	DEG

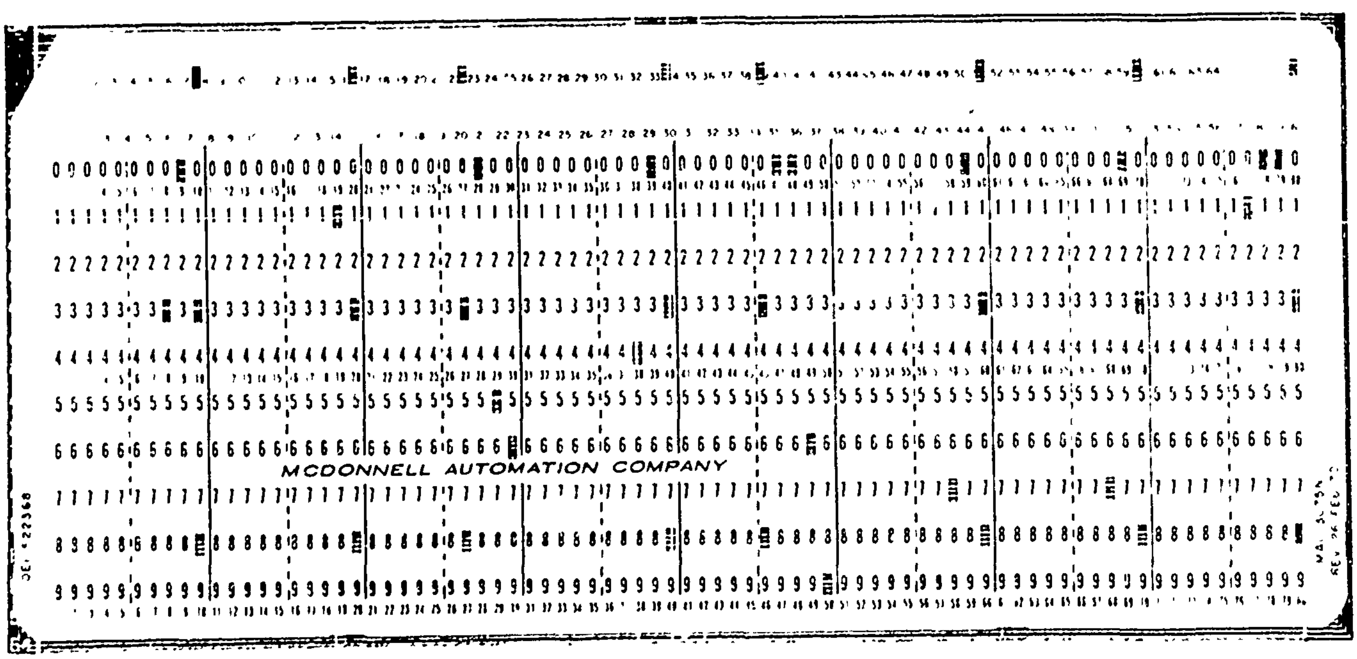
EXAMPLE CARD



CARD NUMBER 2

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	TOTAL LINE LENGTH INCLUDING FITTINGS	IN.
11-20	E10.0	OUTSIDE LINE DIAMETER	IN.
21-30	E10.0	LINE WALL THICKNESS	IN.
31-40	E10.0	LENGTH OF LINE SEGMENT (DELTAX)	IN.
41-50	E10.0	HEAT TRANSFER COEFFICIENT, WALL TO ATMOSPHERE	WATT/IN^2-°F
51-60	E10.0	SURROUNDING STRUCTURE TEMPERATURE	°F
61-70	E10.0	SURROUNDING ATMOSPHERIC TEMPERATURE	°F
71-80	E10.0	HYDRAULIC FLUID INITIAL TEMPERATURE	°F

EXAMPLE CARD



6.0 COMPONENT DATA

Components are classified as anything that is not a line, and includes such things as branches, pumps, reservoirs, valves, actuators, etc.

The cards required to input the data for each component are as follows:

First Card

This card inputs the integer data which includes the component number assigned, the component type number, number of real data cards for the component, and line numbers (either negative or positive depending whether the upstream or downstream end of the line is connected to the component.) Any card data fields not required are to be left blank. All components have pre-assigned connection numbers. The input data assigns line numbers to these component connection numbers. A -ve sign in front of the line number is used if the connection is attached to the upstream end of the line. A +ve number is used to indicate that the component connection is attached to the downstream end of the line.

Following Cards

These input the read data, if any, for the component. The number of real data cards to be read is specified on the first integer card in columns 11-15.

To summarize the component cards are input in the following order.

Component #1	Integer Card Data Cards
Component #2	Integer Card Data Cards

And so on until the number of integer cards read, equals the number of components. It is advisable to keep the component cards in order to avoid confusion and perhaps the chance of having a missing number. The program stops if a number is found to be missing. The data required for each component is described in detail in the following paragraphs.

The components are grouped under general type numbers for convenience.

Type #s	Component Types
1 - 9	Not assigned
10 - 19	Branches
20 - 29	Control Valves
30 - 39	Check Valves
40 - 49	Restrictors
50 - 59	Pumps
60 - 69	Reservoirs/Heat Exchangers
70 - 79	Accumulators
80 - 89	Filters
90 - 99	Control Subroutines
100 - 119	Actuators

If a new component of any above types is to be used in a system, the following changes will have to be made to the program.

1. A new component subroutine must be created. The name should be similar to the old name except for the last digit which should be the next available digit in the sequence.
2. The new subroutine call must be added to TCOMPA subroutine in its respective group.
3. Make any necessary changes to TCOMPA to allow isolation and control to be passed to the new component subroutine.

4. The initialization data for the new component subroutine must be added to Block Data (See Volume II).

5. The new subroutine must then be loaded into the file being used.

Example

Newly created accumulator subroutine would be named TACUM72. TCOMPA would be changed to the following.

```
. . . . . . . . . .
270 CONTINUE
    GO TO (271,272,400), KTYPE-70
271 CALL TACUM71 (D(N1),D(N2),DD(N3),L(N4))
    GO TO 400
272 CALL TACUM72 (D(Ni),D(N2),DD(N3),L(N4))
    GO TO 400
280 CONTINUE
. . . . . . . . . .
```

6.10 BRANCHES

A branch is a connection used to join two or more lines or to cap off a line. The following is currently included in the program.

TYPE #11 Frictionless Branch (TBRAN11)

6.11 FRICTIONLESS BRANCH

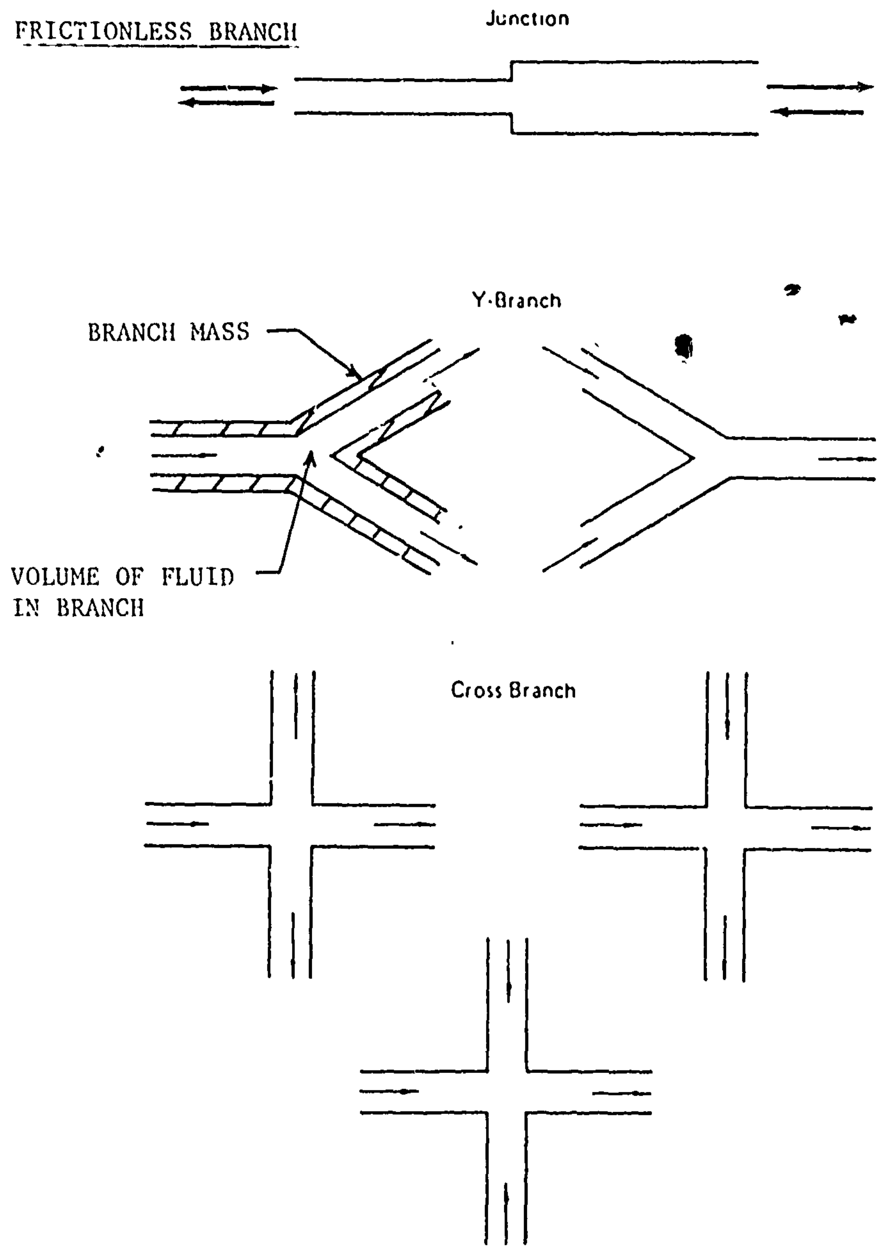


FIGURE 6.11-1

Type No. 11 Frictionless Branch

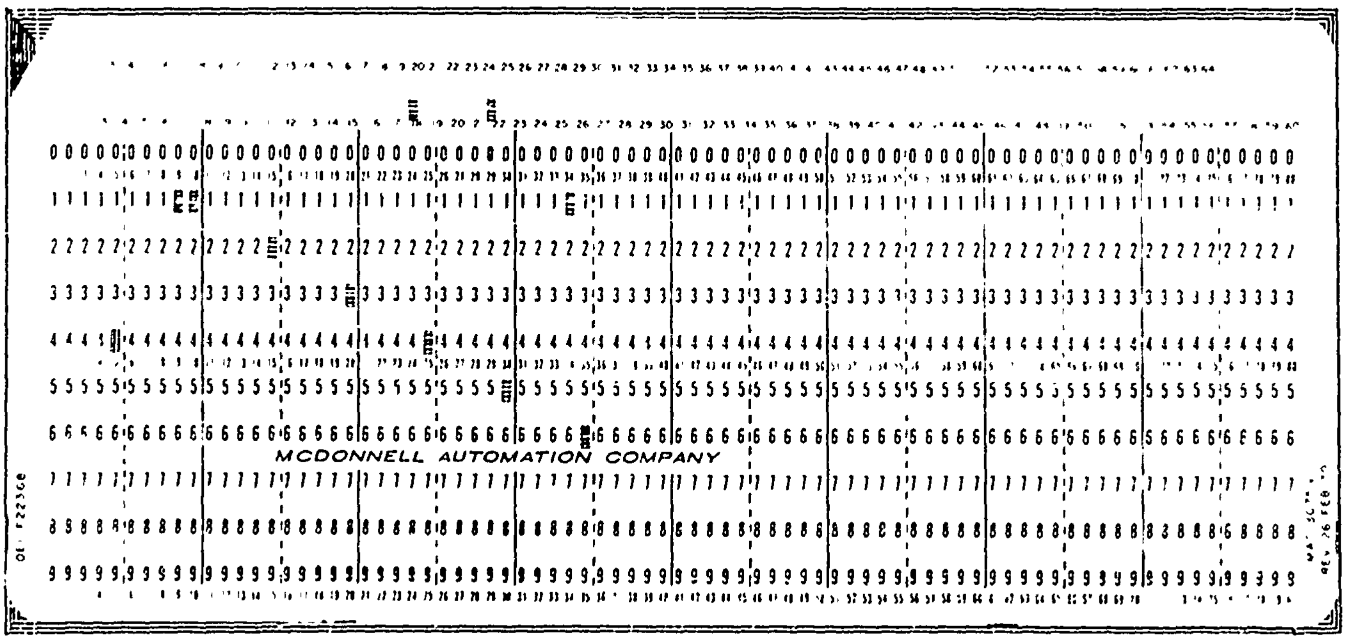
Type 11 is a frictionless branch with one through four connections. With one connecting line, the line is blanked off. With two connecting lines, the branch becomes a union between the two lines. With three or four connections the branch becomes a "Y" or "T" or a "cross", respectively. The branch fluid and wall temperatures are calculated.

TBRAN11

CARD NUMBER 1

COLUMN	FORMAT	DATA
1-5	I5	Component Number
6-10	I5	Type Number = 11
11-15	I5	Number of Real Data Cards = 2
16-20	I5	Line Number (with sign) attached to Connection 1
21-25	I5	Line Number (with sign) attached to Connection 2
26-30	I5	Line Number (with sign) attached Connection 3
31-35	I5	Line Number (with sign) attached to Connection 4
36-40	I5	
41-45	I5	
46-50	I5	
51-55	I5	
56-60	I5	
61-65	I5	
66-70	I5	
71-75	I5	
76-80	I5	

EXAMPLE CARD

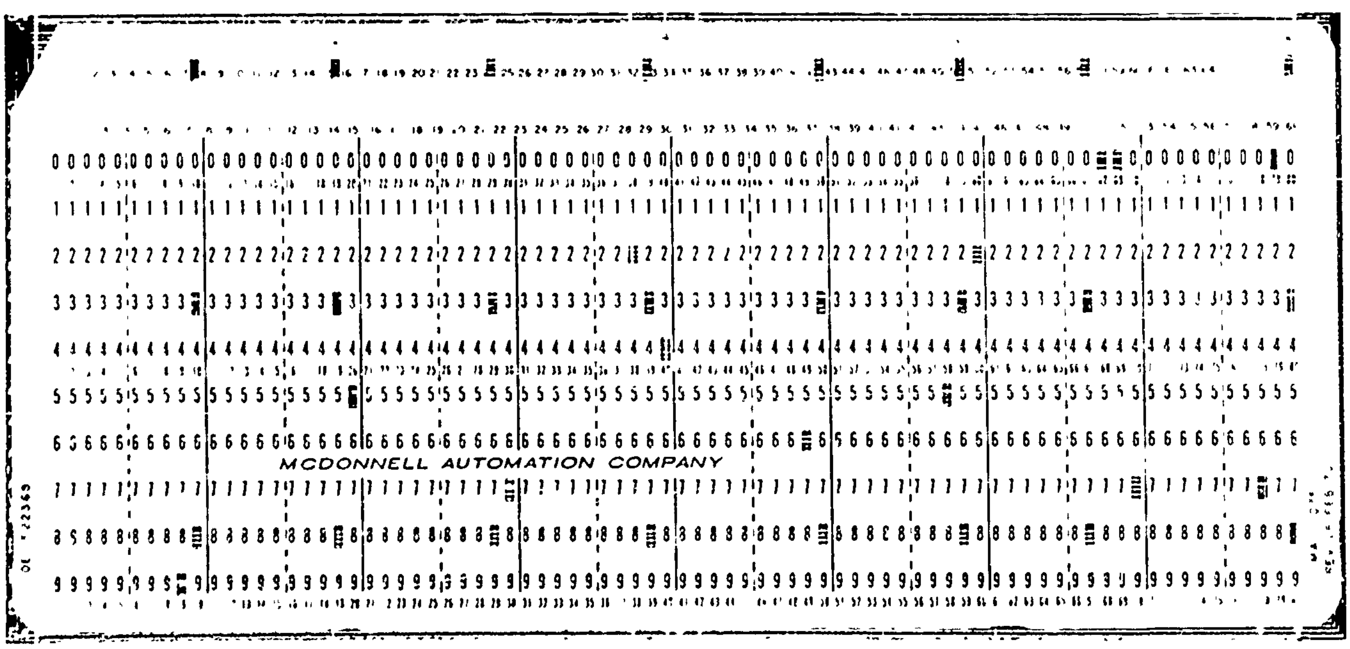


TBRAN11

CARD NUMBER 2

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	BRANCH MATERIAL TYPE	--
11-20	E10.0	BRANCH MASS	LB_m
21-30	E10.0	VOLUME OF FLUID IN BRANCH	CUBIC IN.
31-40	E10.0	AVERAGE DISTANCE FROM INLET TO OUTLET (ALL COMBINATIONS INCLUDED)	IN.
41-50	E10.0	EXTERNAL SURFACE AREA OF BRANCH	$IN.^2$
51-60	E10.0	SURFACE AREA FLUID TO BRANCH CASE	$IN.^2$
61-70	E10.0	HEAT TRANSFER COEFF. BRANCH TO ATMOSPHERE	$WATT/IN^2-°F$
71-80	E10.0	TEMPERATURE OF SURROUNDING STRUCTURE	°F

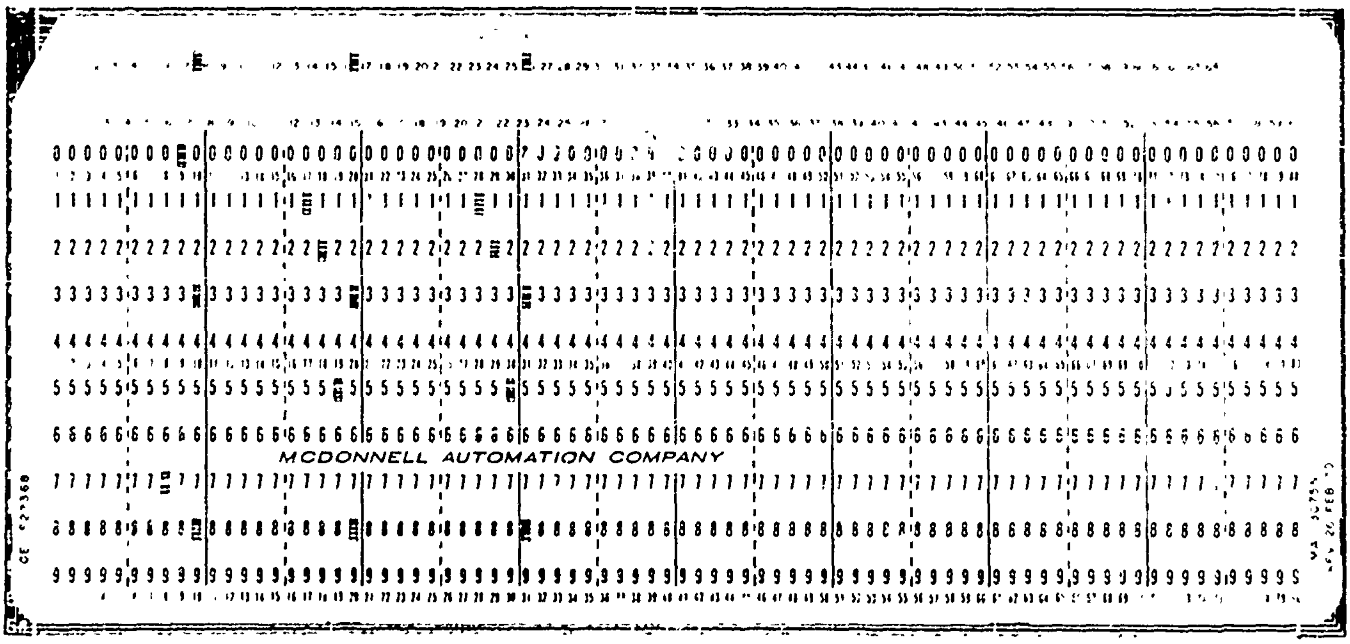
EXAMPLE CARD



CARD NUMBER 3

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	SURROUNDING ATMOSPHERIC TEMPERATURE	°F
11-20	E10.0	INITIAL TEMPERATURE OF BRANCH FLUID	°F
21-30	E10.0	INITIAL TEMPERATURE OF BRANCH WALLS	°F
31-40	E10.0		
41-50	E10.0		
51-60	E10.0		
61-70	E10.0		
71-80	E10.0		

EXAMPLE CARD



6.20 CONTROL VALVES

Control valves, either shut-off or modulating type, can be simulated by inputting the valve opening characteristics versus time. The following are currently included in the program.

Type #21 Two-way Control Valve (TVALV21)

Type #22 Three-way or Four-Way Valve (TVALV22)

6.20 CONTROL VALVES

Control valves, either shut-off or modulating type, can be simulated by inputting the valve opening characteristics versus time. The following are currently included in the program.

Type #21 Two-way Control Valve (TVALV21)

Type #22 Three-way or Four-Way Valve (TVALV22)

6.21 TYPE #21 TWO-WAY CONTROL VALVE

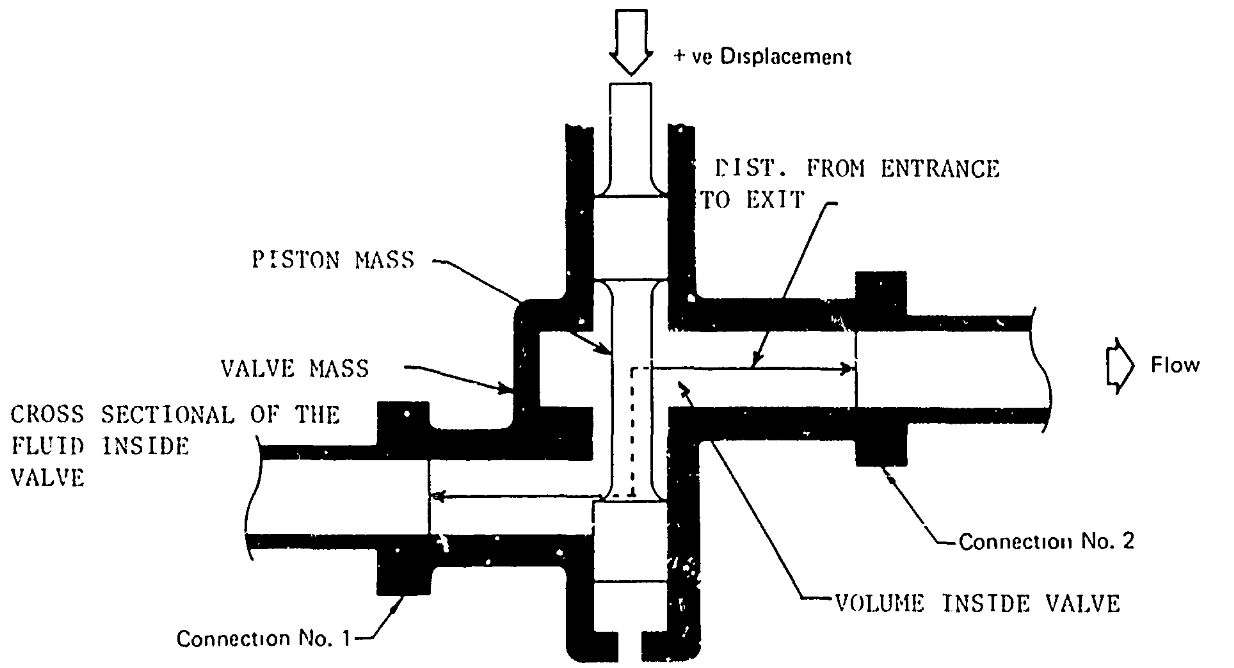


FIGURE 6.21-1
TYPE NO. 21 TWO-WAY VALVE

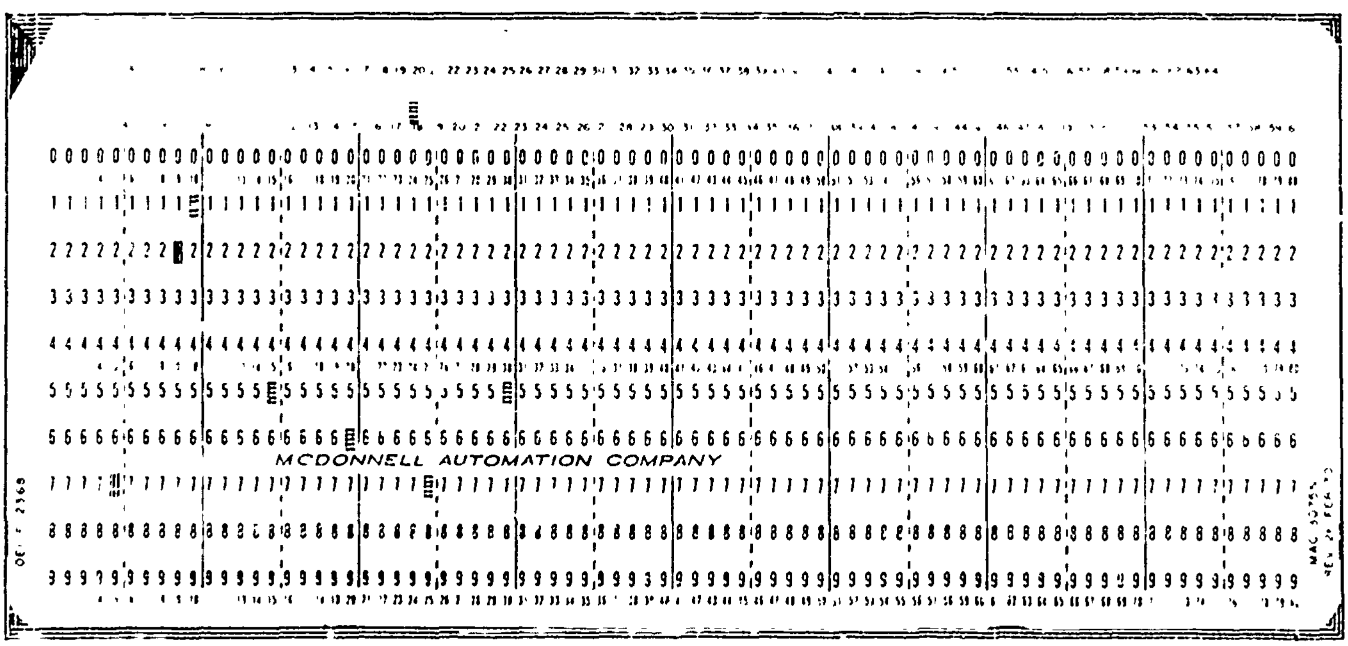
Type #21 valve uses an externally controlled time history input. The valve opening versus time derived from the tabulated data input on the fifth and sixth data cards. The total number input on both the time and displacement tables must be equal to the number input in columns 26-30 of card number one. The valve fluid and wall temperatures are calculated.

TVALV21

CARD NUMBER 1

COLUMN	FORMAT	DATA
1-5	I5	Component Number
6-10	I5	Type Number = 21
11-15	I5	Number of Real Data Cards = 4 or more
16-20	I5	Line Number (with sign) attached to Connection 1
21-25	I5	Line Number (with sign) attached to Connection 2
26-30	I5	Number of data points in table
31-35	I5	
36-40	I5	
41-45	I5	
46-50	I5	
51-55	I5	
56-60	I5	
61-65	I5	
66-70	I5	
71-75	I5	
76-80	I5	

EXAMPLE CARD

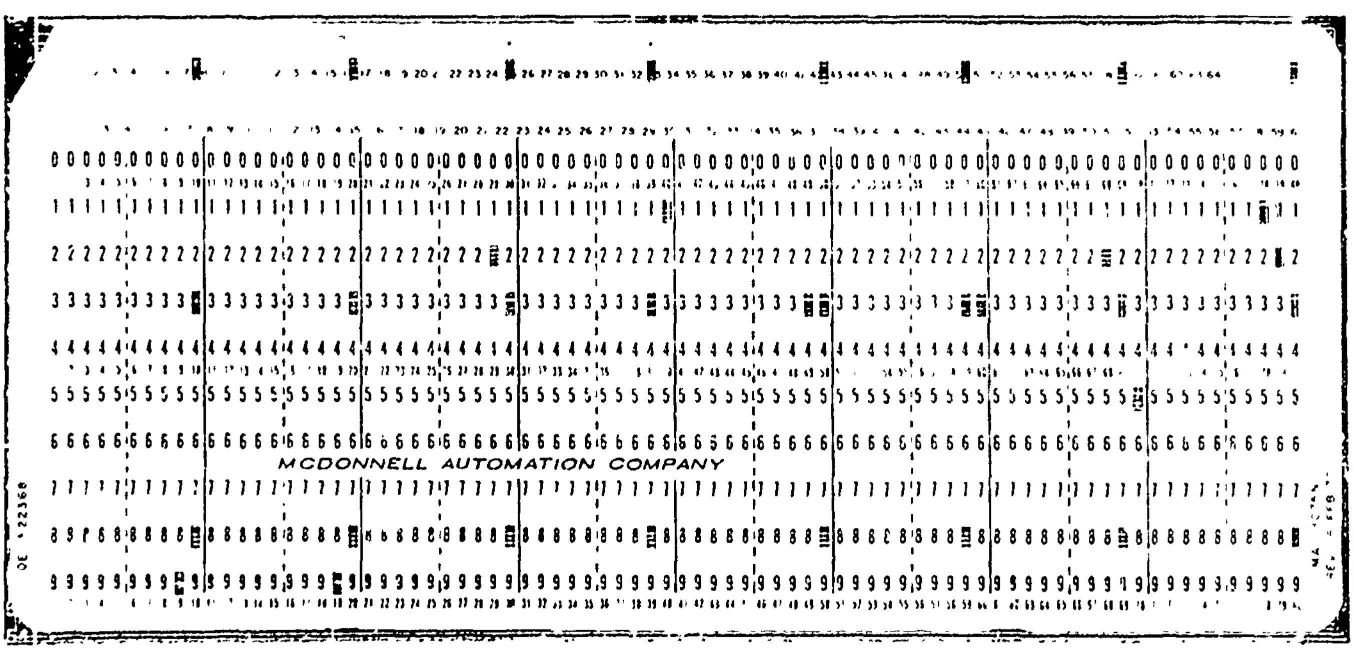


TVALV21

CARD NUMBER 2

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	VALVE MATERIAL TYPE	--
11-20	E10.0	PISTON MATERIAL TYPE	--
21-30	E10.0	VALVE MASS	LBm
31-40	E10.0	PISTON MASS	LBm
41-50	E10.0	DISTANCE FROM ENT. TO EXIT OF VALVE	IN.
51-60	E10.0	VOLUME INSIDE VALVE	$IN.^3$
61-70	E10.0	SURFACE AREA ATMOSPHERE TO VALVE WALL	$IN.^2$
71-80	E10.0	SURFACE AREA FLUID TO VALVE WALL	$IN.^2$

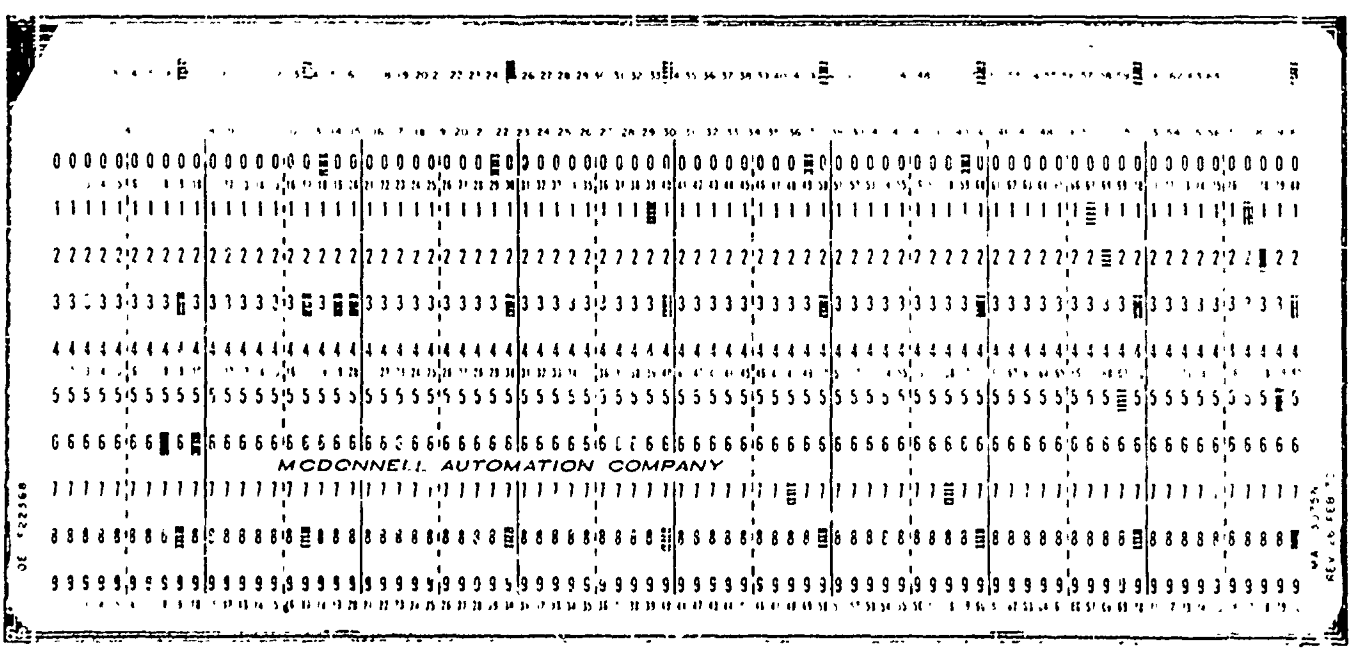
EXAMPLE CARD



CARD NUMBER 3

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	SURFACE AREA FLUID TO PISTON	IN.^{2}
11-20	E10.0	CROSS SECTIONAL AREA OF THE FLUID INSIDE VALVE OR AT ENTRANCE	IN.^{2}
21-30	E10.0	HEAT TRANSFER COEFF. ATMOSPHERE TO VALVE	WATT/IN.^{2}-°F
31-40	E10.0	PERCENTAGE HEAT ADDED TO FLUID (DUE TO ΔP)	
41-50	E10.0	SURROUNDING STRUCTURE TEMPERATURE	°F
51-60	E10.0	SURROUNDING ATMOSPHERE TEMPERATURE	°F
61-70	E10.0	INITIAL TEMPERATURE OF THE FLUID	°F
71-80	E10.0	INITIAL TEMPERATURE OF THE VALVE WALLS	°F

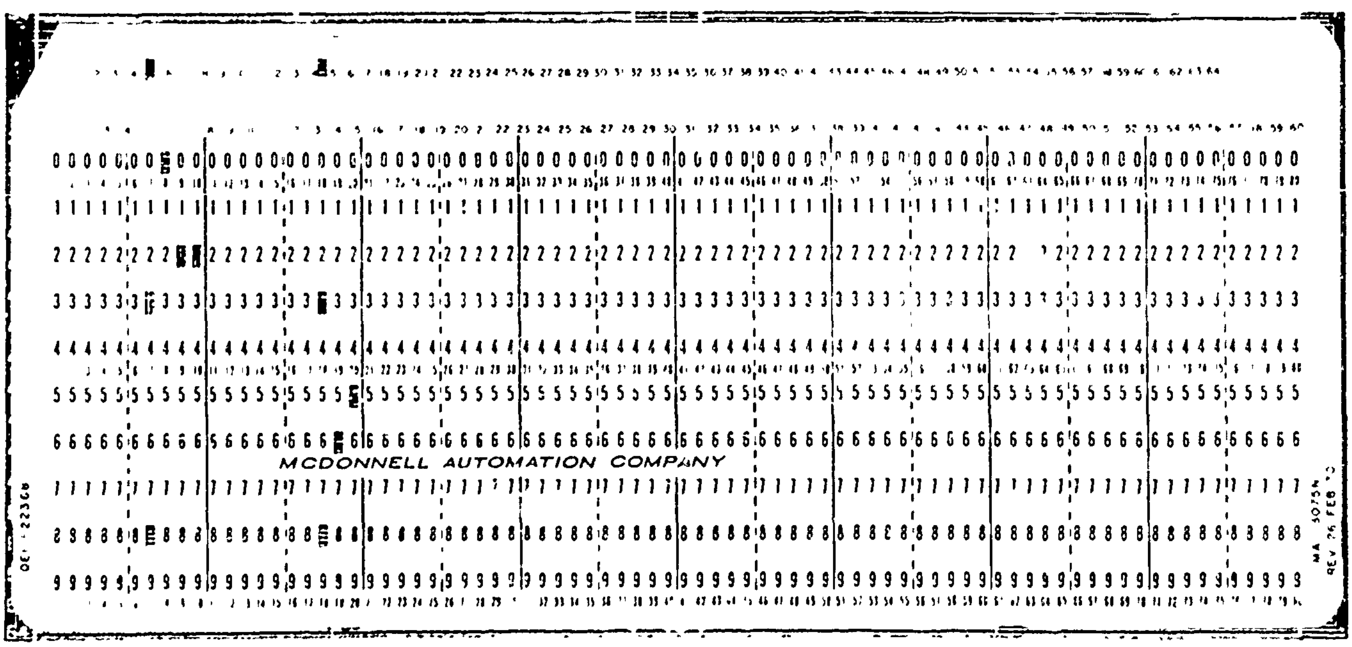
EXAMPLE CARD



CARD NUMBER 4

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	VALVE SLOT WIDTH	IN.
11-20	E10.0	DISCHARGE COEFF.	---
21-30	E10.0		
31-40	E10.0		
41-50	E10.0		
51-60	E10.0		
61-70	E10.0		
71-80	E10.0		

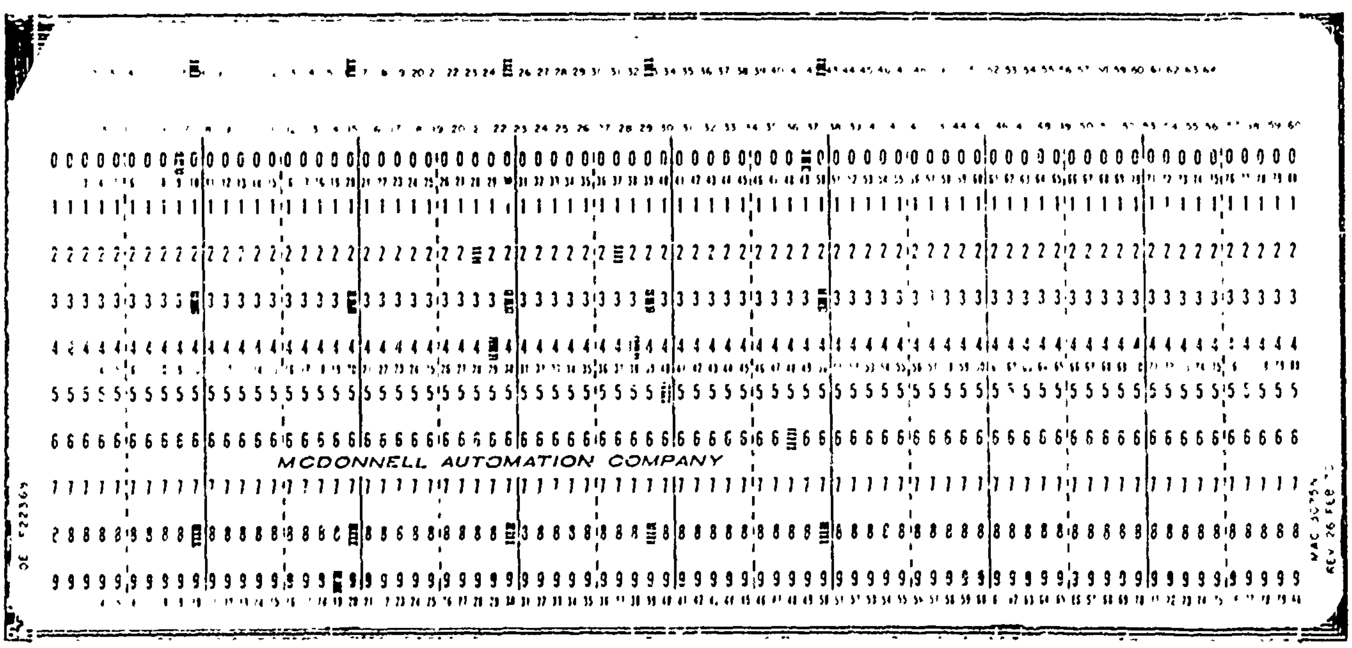
EXAMPLE CARD



CARD NUMBER 5

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	First Time Valve - Should Be 0.0	Sec.
11-20	E10.0	(Enter As Many Time Values As	Sec.
21-30	E10.0	Required Using As Many Columns	
31-40	E10.0	and Cards As Necessary - Final time	
41-50	E10.0	Should Be the Final Calculation Time).	
51-60	E10.0		
61-70	E10.0		
71-80	E10.0		

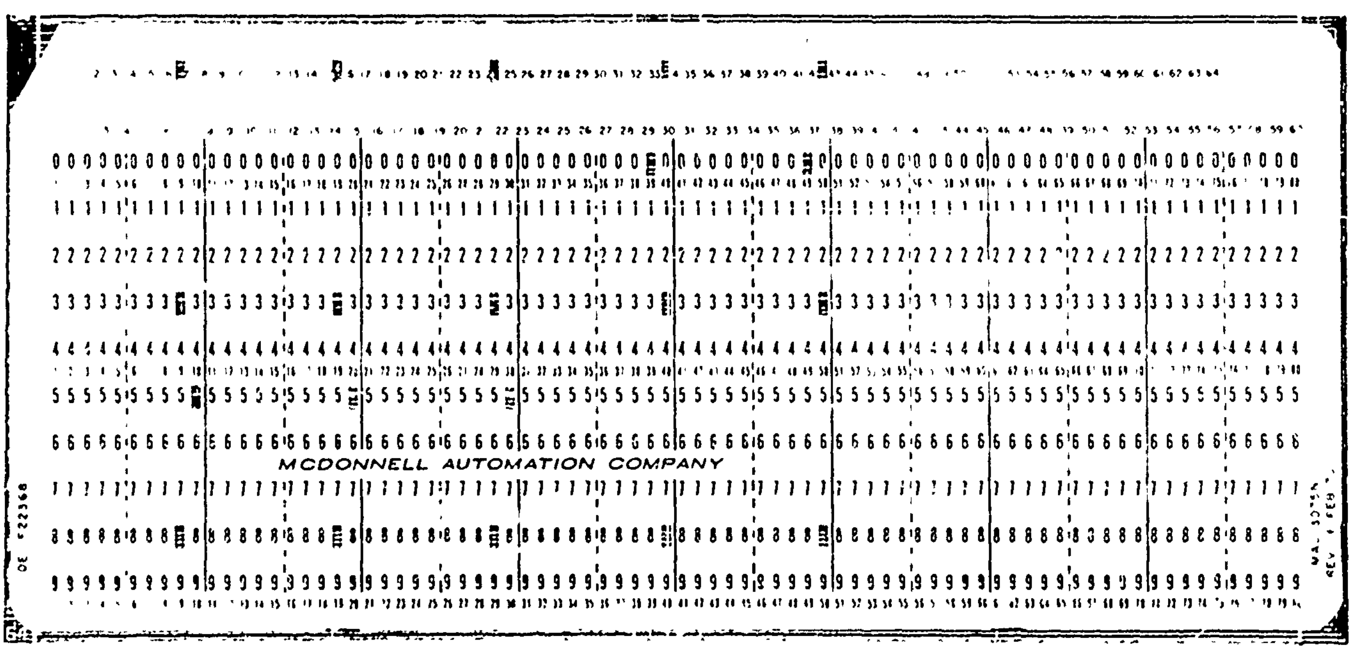
EXAMPLE CARD



CARD NUMBER 6

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	Initial Valve Position @ T = 0.0	IN.
11-20	E10.0	(Enter As Many Valve Positions	
21-30	E10.0	As Time Values).	
31-40	E10.0		
41-50	E10.0		
51-60	E10.0		
61-70	E10.0		
71-80	E10.0		

EXAMPLE CARD



6.22 TYPE #22 FOUR-WAY/THREE-WAY CONTROL VALVE

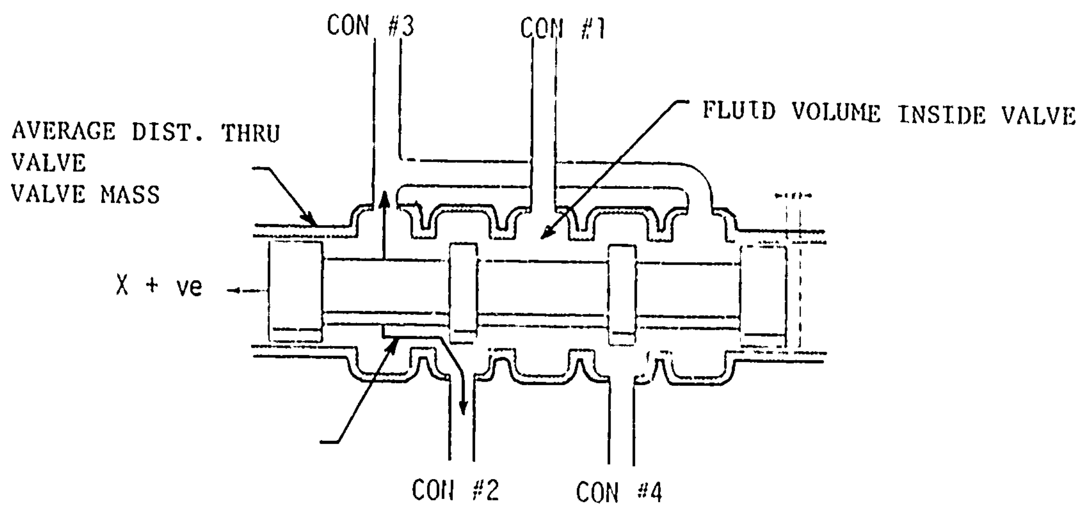


FIGURE 6.22-1

TYPE NO. 22 FOUR-WAY VALVE

The Type #22 valve can be used either as a four-way or three-way control valve with an externally controlled time history input. The valve opening versus time is derived from the tabulated input data. Valve fluid temperatures are calculated along with the valve wall temperature.

The valve model can handle any or all ports flowing simultaneously and if necessary, all or any group may open in the same direction. The center position of the valve is just a reference point. To input the data for the valve it is necessary to know the approximate characteristics to be simulated such as valve overlap; open center underlap, etc.

The valve opening versus position characteristics are described separately for each port. The description is the same for each one and if all inputs were identical the valve areas of each port would be equal versus valve position.

The user should choose from the family of curves in Figures 6.22-2 the valve area versus position characteristic best suited to his valve. The next task is to determine the projected cutoff and the max opening position which will give the required area slope. It should be noted that either of these two values may be beyond the input position range. Additional non-linearity can be simulated by the use of non-linear position versus time input.

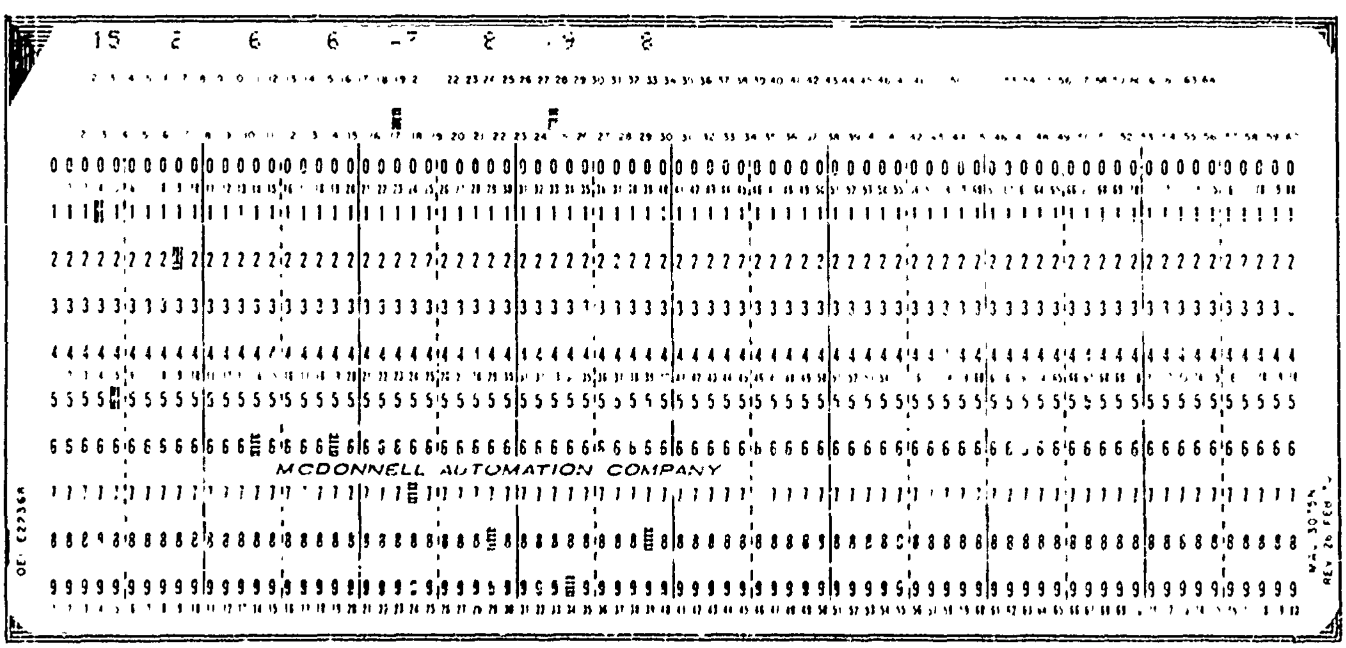
Typical plots of valve area versus position, for the input card data are given in Figure 6.22-3.

TVALV22

CARD NUMBER 1

COLUMN	FORMAT	DATA
1-5	I5	Component Number
6-10	I5	Type Number = 22
11-15	I5	Number of Real Data Cards = 5 or more
16-20	I5	Line Number (with sign) attached to Connection 1
21-25	I5	Line Number (with sign) attached to Connection 2
26-30	I5	Line Number (with sign) attached to Connection 3
31-35	I5	Line Number (with sign) attached to Connection 4
36-40	I5	Number of Data Points on the Time Data Table
41-45	I5	
46-50	I5	
51-55	I5	
56-60	I5	
61-65	I5	
66-70	I5	
71-75	I5	
76-80	I5	

EXAMPLE CARD

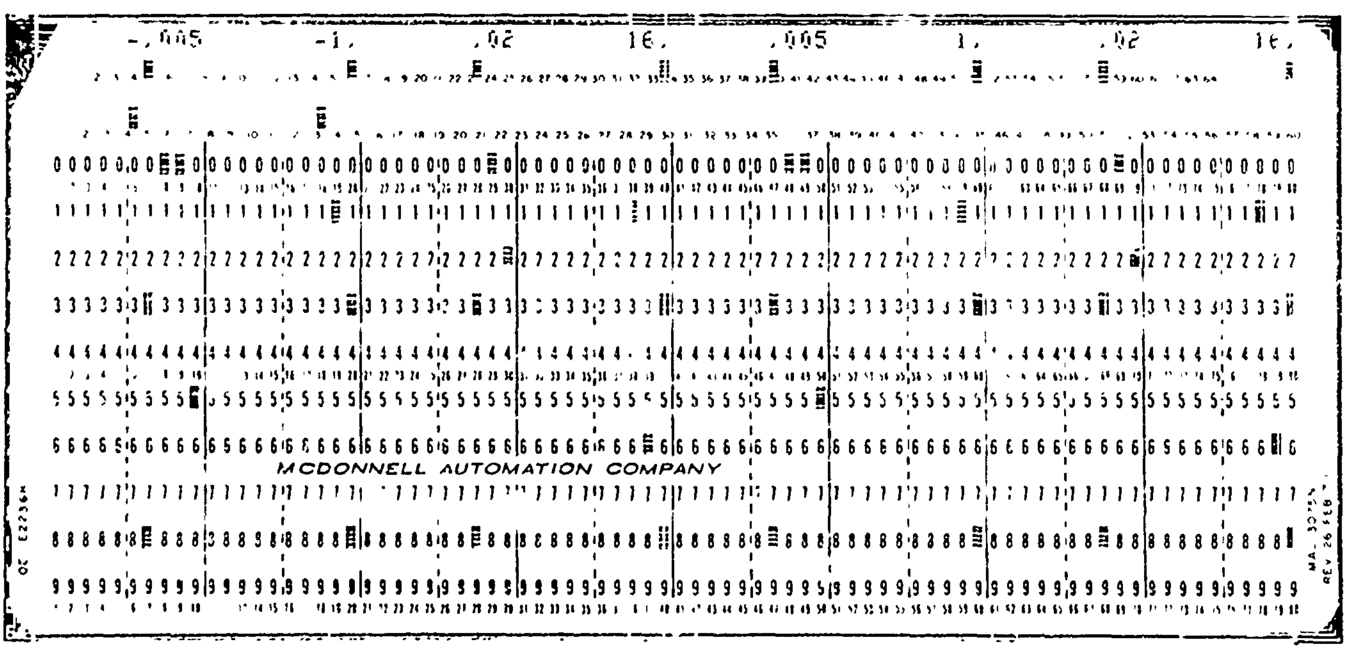


TVALV22

CARD NUMBER 2

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	CON #1-2 PROJECTED CUTOFF POSITION	IN
11-20	E10.0	CON #1-2 PROJECTED MAX OPENING POSITION	IN
21-30	E10.0	CON #1-2 MAX EFFECTIVE VALVE AREA	IN^2
31-40	E10.0	CON #1-2 CHARACTERISTIC CURVATURE COEFF.	-
41-50	E10.0	CON #2-3 PROJECTED CUTOFF POSITION	IN
51-60	E10.0	CON #2-3 PROJECTED MAX OPENING POSITION	IN
61-70	E10.0	CON #2-3 MAX EFFECTIVE VALVE AREA	IN^2
71-80	E10.0	CON #2-3 CHARACTERISTIC CURVATURE COEFF.	-

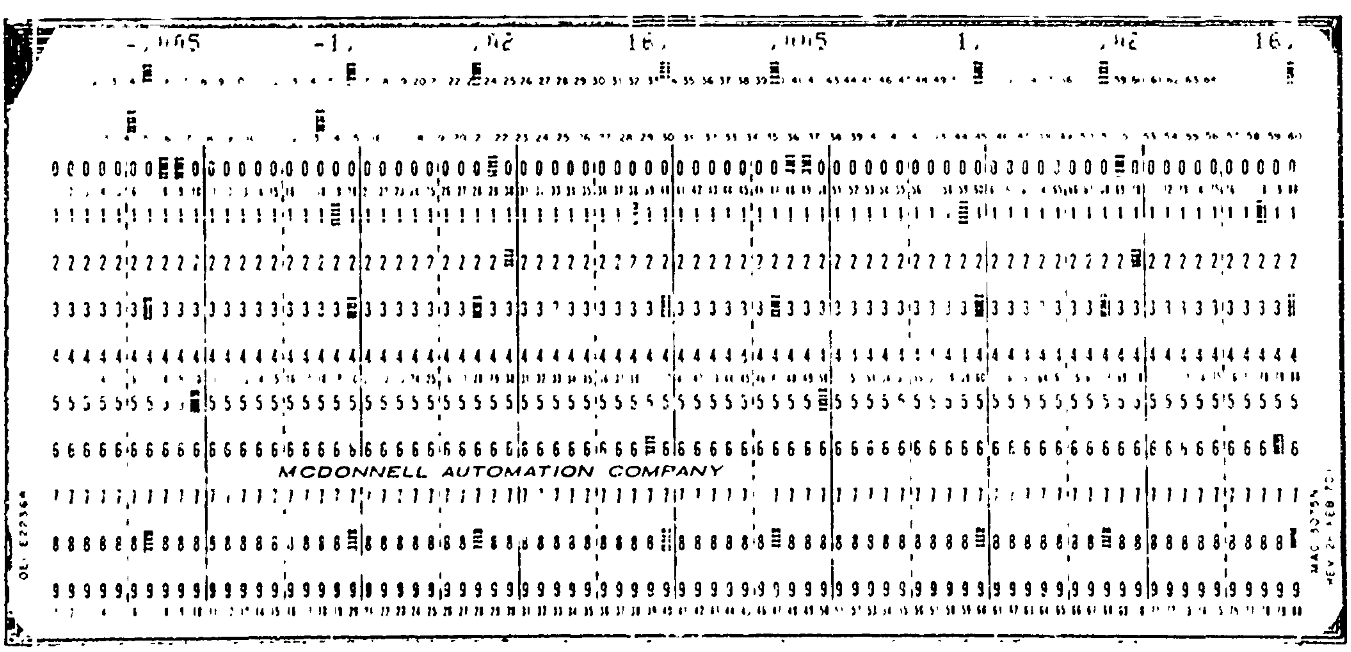
EXAMPLE CARD



CARD NUMBER 3

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	CON #3-4 PROJECTED CUTOFF POSITION	IN
11-20	E10.0	CON #3-4 PROJECTED MAX OPENING POSITION	IN
21-30	E10.0	CON #3-4 MAX EFFECTIVE VALVE AREA	IN^2
31-40	E10.0	CON #3-4 CHARACTERISTIC CURVATURE COEFF.	
41-50	E10.0	CON #4-1 PROJECTED CUTOFF POSITION	IN
51-60	E10.0	CON #4-1 PROJECTED MAX OPENING POSITION	IN
61-70	E10.0	CON #4-1 MAX. EFFECTIVE VALVE AREA	IN^2
71-80	E10.0	CON #4-1 CHARACTERISTIC CURVATURE COEFF.	

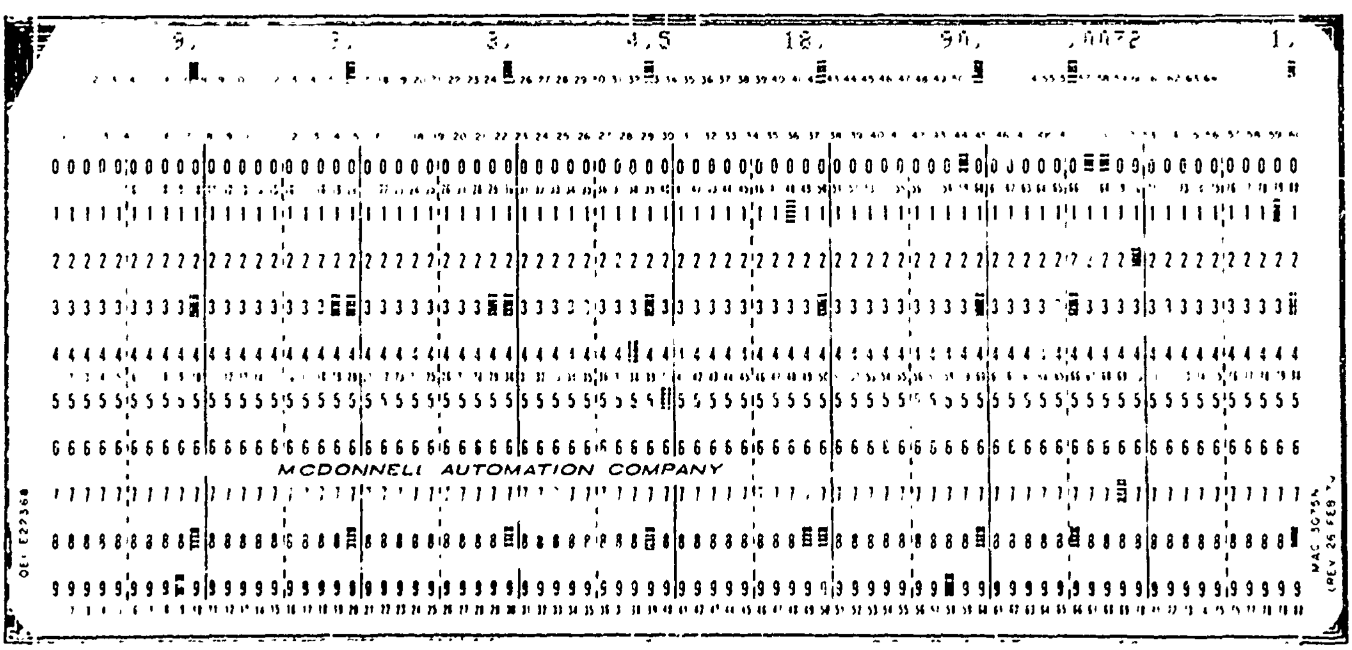
EXAMPLE CARD



CARD NUMBER 4

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	VALVE MATERIAL TYPE	--
11-20	E10.0	VALVE MASS	LBm
21-30	E10.0	FLUID VOLUME INSIDE VALVE	$IN.^3$
31-40	E10.0	AVERAGE DISTANCE THRU VALVE INLETS TO OUTLETS	IN.
41-50	E10.0	SURFACE AREA FLUID TO VALVE WALL	$IN.^2$
51-60	E10.0	SURFACE AREA VALVE CASE TO ATMOSPHERE	$IN.^2$
61-70	E10.0	HEAT TRANSFER COEFF VALVE CASE TO ATMOSPHERE	$WATT/IN^2$-°F
71-80	E10.0	PERCENTAGE HEAT ADDED TO FLUID (DUE TO ΔP)	--

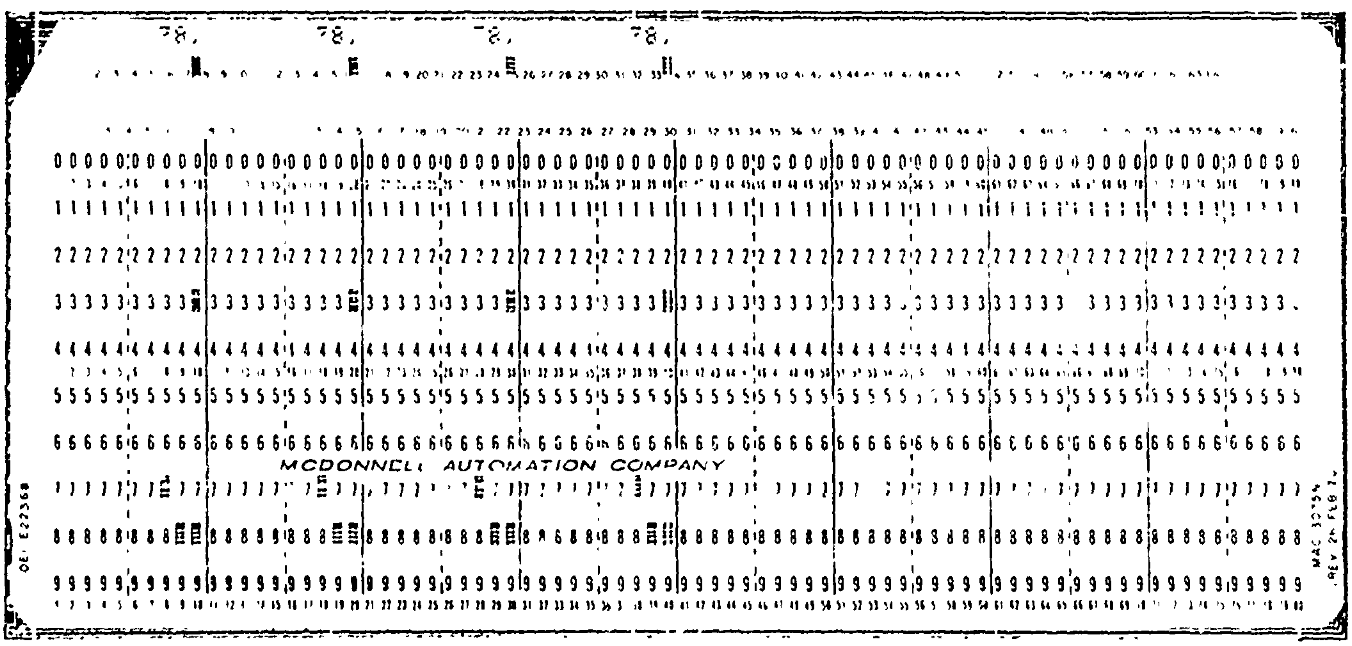
EXAMPLE CARD



CARD NUMBER 5

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	TEMPERATURE OF SURROUNDING STRUCTURE	°F
11-20	E10.0	TEMPERATURE OF SURROUNDING ATMOSPHERE	°F
21-30	E10.0	INITIAL TEMPERATURE OF FLUID	°F
31-40	E10.0	INITIAL TEMPERATURE OF VALVE CASE	°F
41-50	E10.0	CROSS SECTIONAL AREA OF THE FLUID PATH IN THE VALVE	$IN.^2$
51-60	E10.0		
61-70	E10.0		
71-80	E10.0		

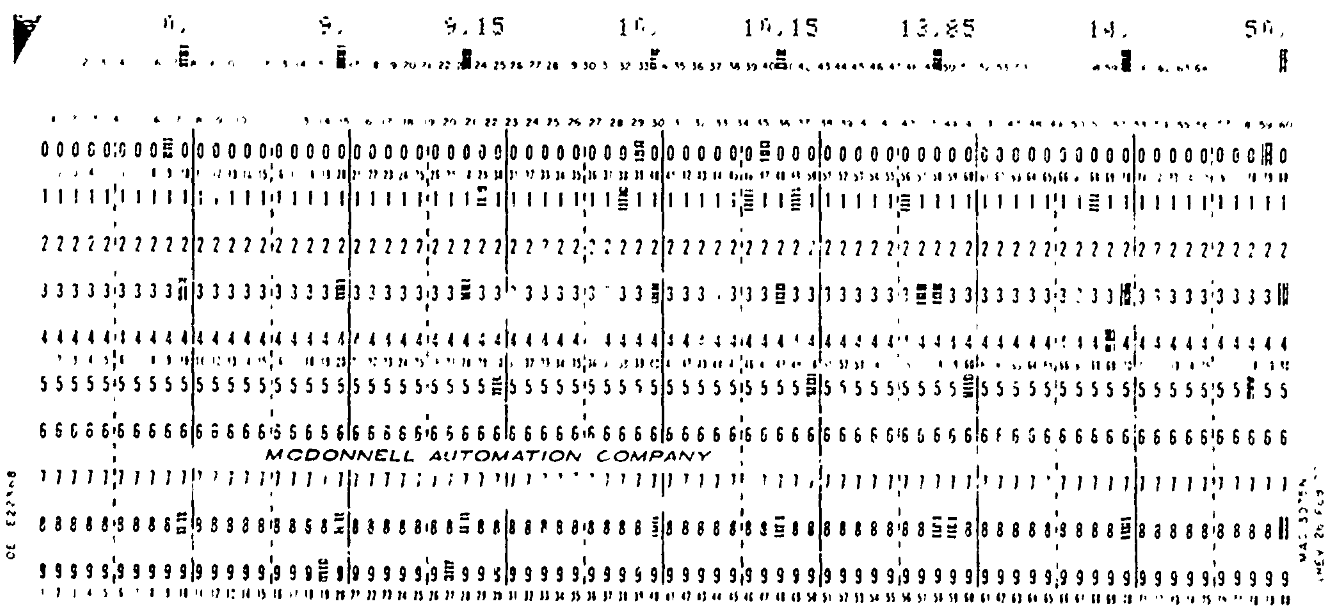
EXAMPLE CARD



CARD NUMBER 6

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	FIRST TIME VALUE - SHOULD BE 0	SEC
11-20	E10.0	(ENTER AS MANY TIME VALUES	
21-30	E10.0	AS REQUIRED USING AS MANY	
31-40	E10.0	COLUMNS AND CARDS AS	
41-50	E10.0	NECESSARY - FINAL TIME	
51-60	E10.0	SHOULD BE FINAL CALCULATION	
61-70	E10.0	TIME).	
71-80	E10.0		

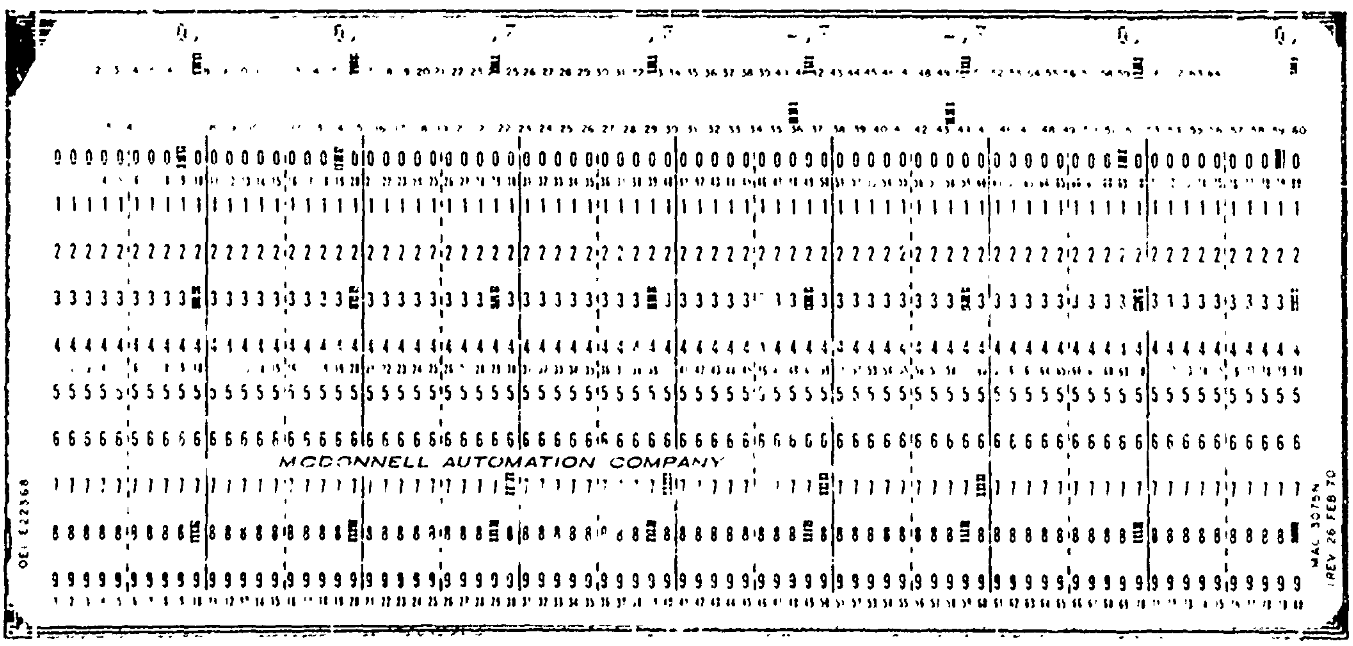
EXAMPLE CARD



CARD NUMBER 7

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	Initial Valve Position @ T = 0	In.
11-20	E10.0	(Enter as Many Valve Positions	
21-30	E10.0	as Time Values)	
31-40	E10.0		
41-50	E10.0		
51-60	E10.0		
61-70	E10.0		
71-80	E10.0		

EXAMPLE CARD



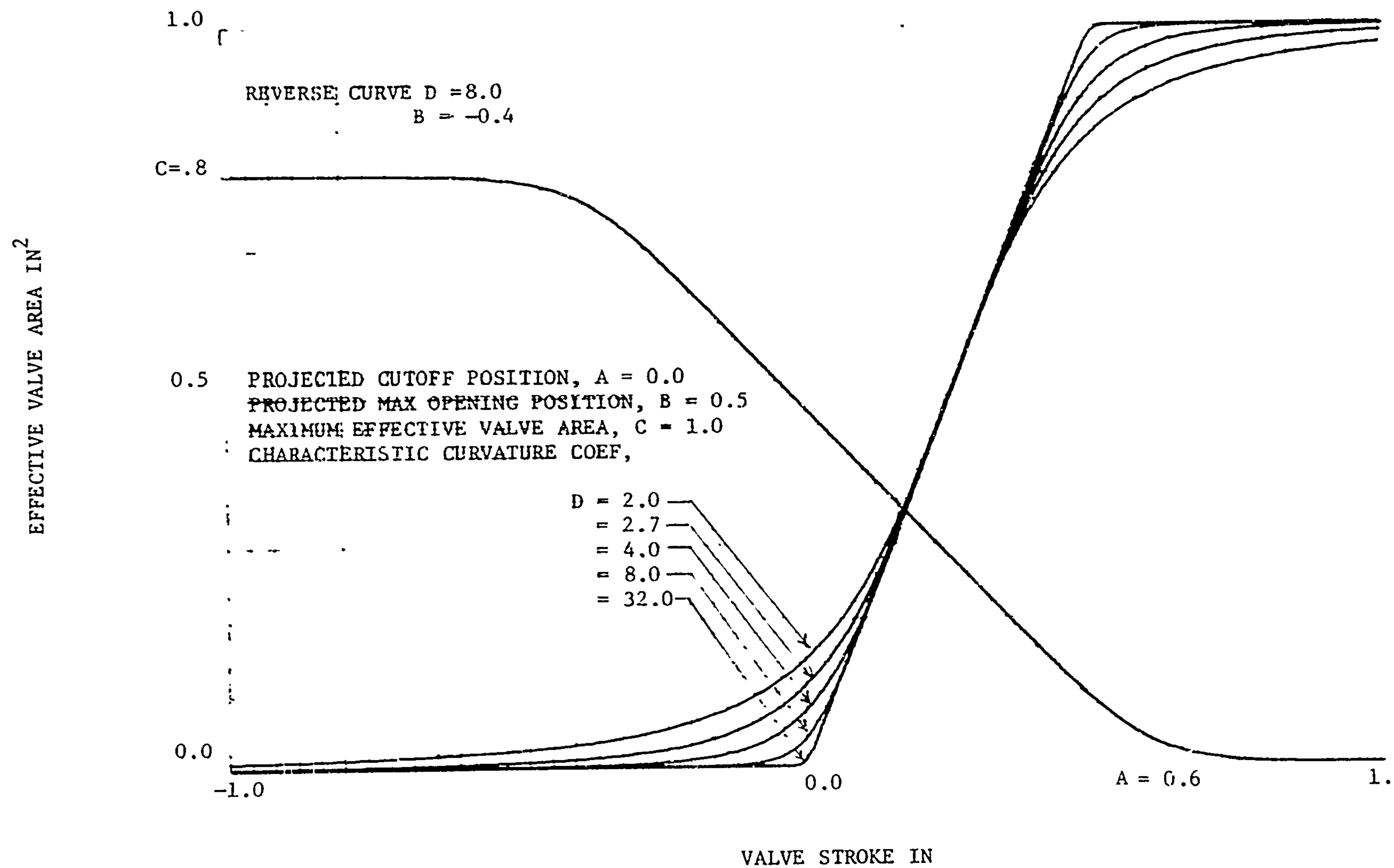


FIGURE 6.22-2
EFFECTIVE VALVE AREA CHARACTERISTICS

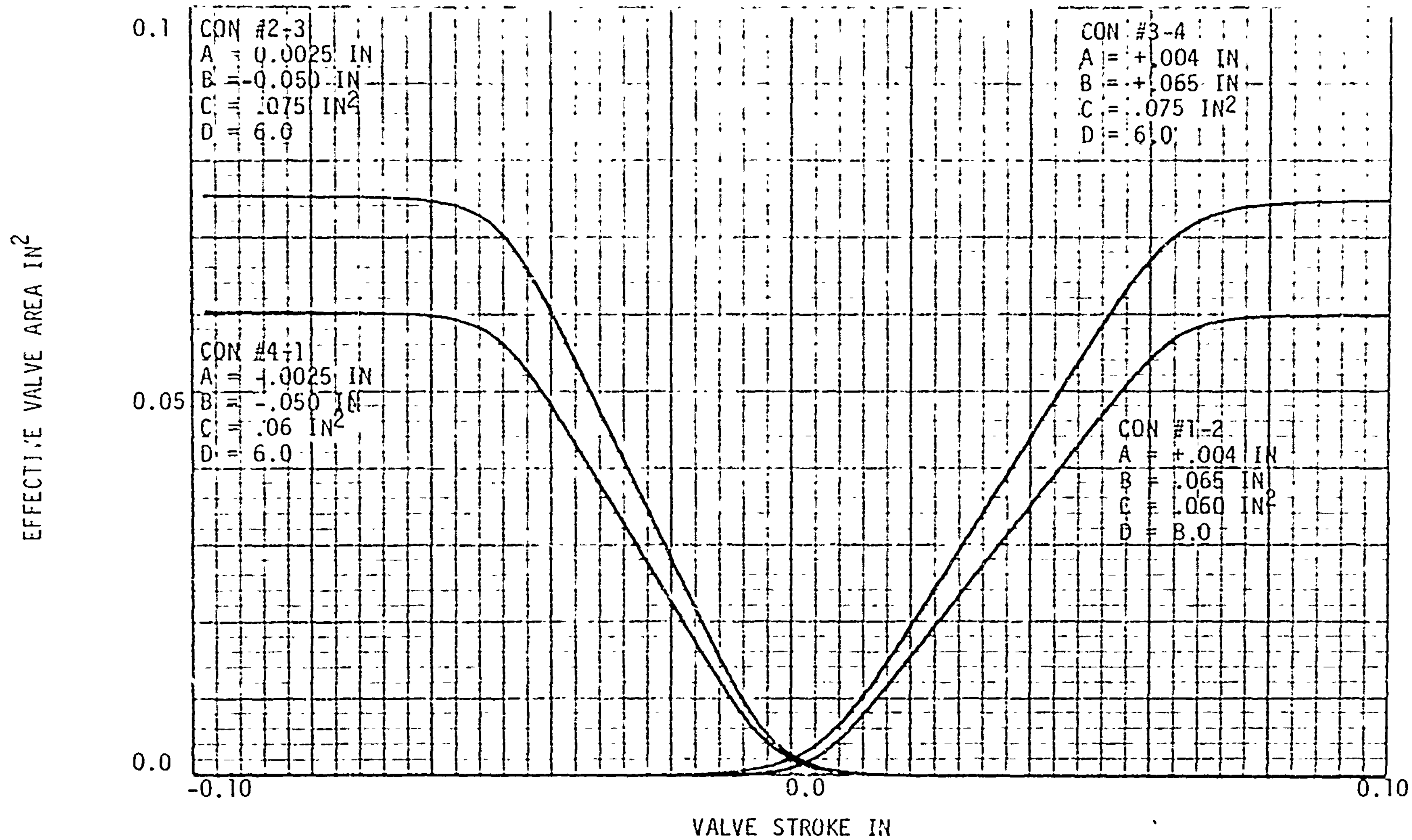


FIGURE 6.22-3
EFFECTIVE VALVE AREA VERSUS POSITION
FOR EXAMPLE DATA

6.30 CHECK VALVES

Check valves either completely restrict the flow or let it pass without any appreciable obstruction. The following type is currently included in the program.

Type #31 Undamped Check Valve (TCVAL31)

6.31 TYPE #31 UNDAMPED CHECK VALVE

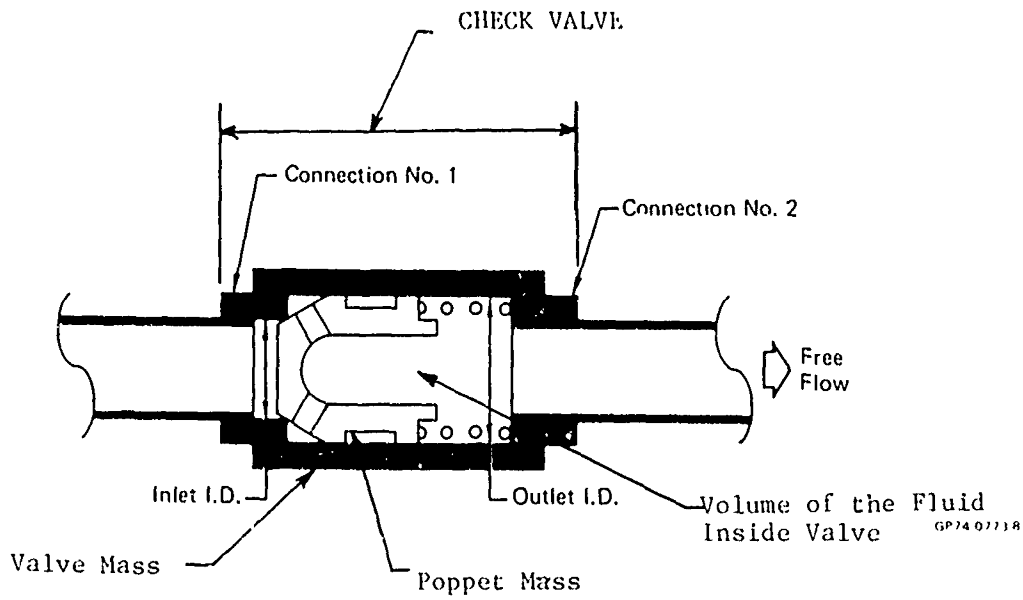


FIGURE 6.31-1
TYPE NO. 31 CHECK VALVE

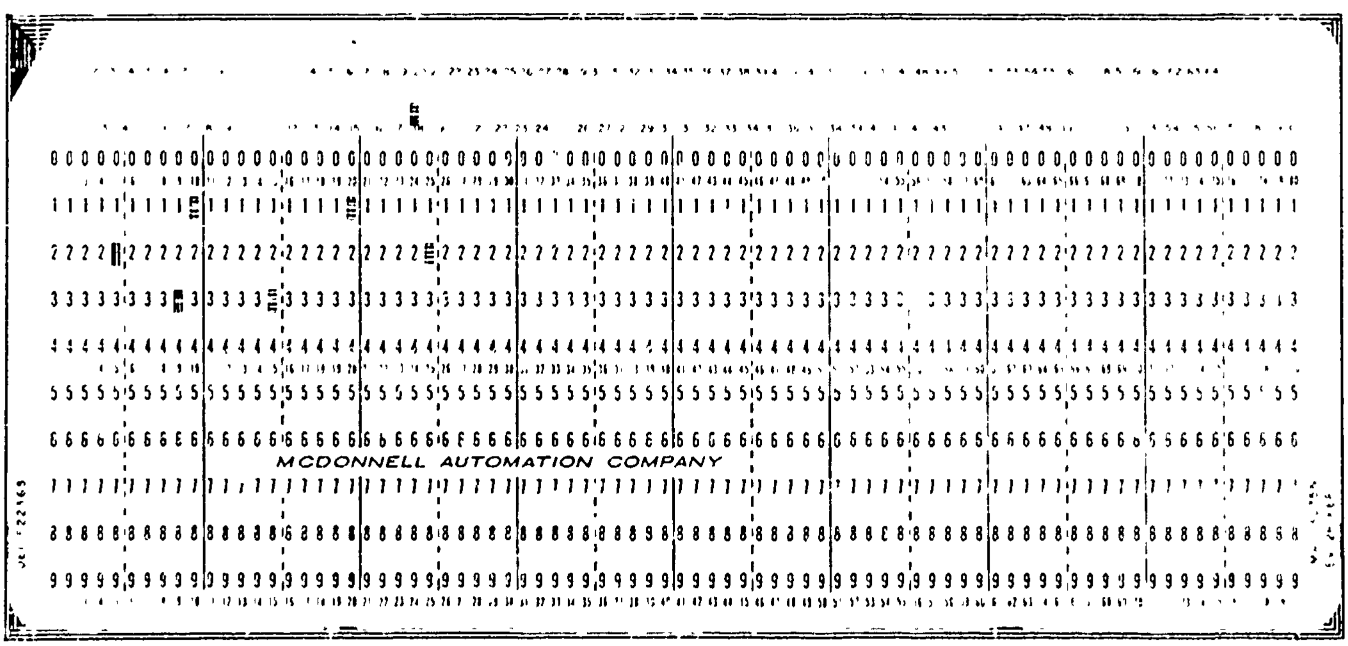
Check valve Type #31 can open and close during operation without any damping or displacement characteristics. The valve may be in any open position, depending on flow, or completely closed. The check valve and fluid wall temperatures are computed.

TCVAL31

CARD NUMBER 1

COLUMN	FORMAT	DATA
1-5	I5	Component Number
6-10	I5	Type Number = 31
11-15	I5	Number of Real Data Cards = 3
16-20	I5	Line Number (with sign) attached to Connection 1
21-25	I5	Line Number (with sign) attached to Connection 2
26-30	I5	
31-35	I5	
36-40	I5	
41-45	I5	
46-50	I5	
51-55	I5	
56-60	I5	
61-65	I5	
66-70	I5	
71-75	I5	
76-80	I5	

EXAMPLE CARD

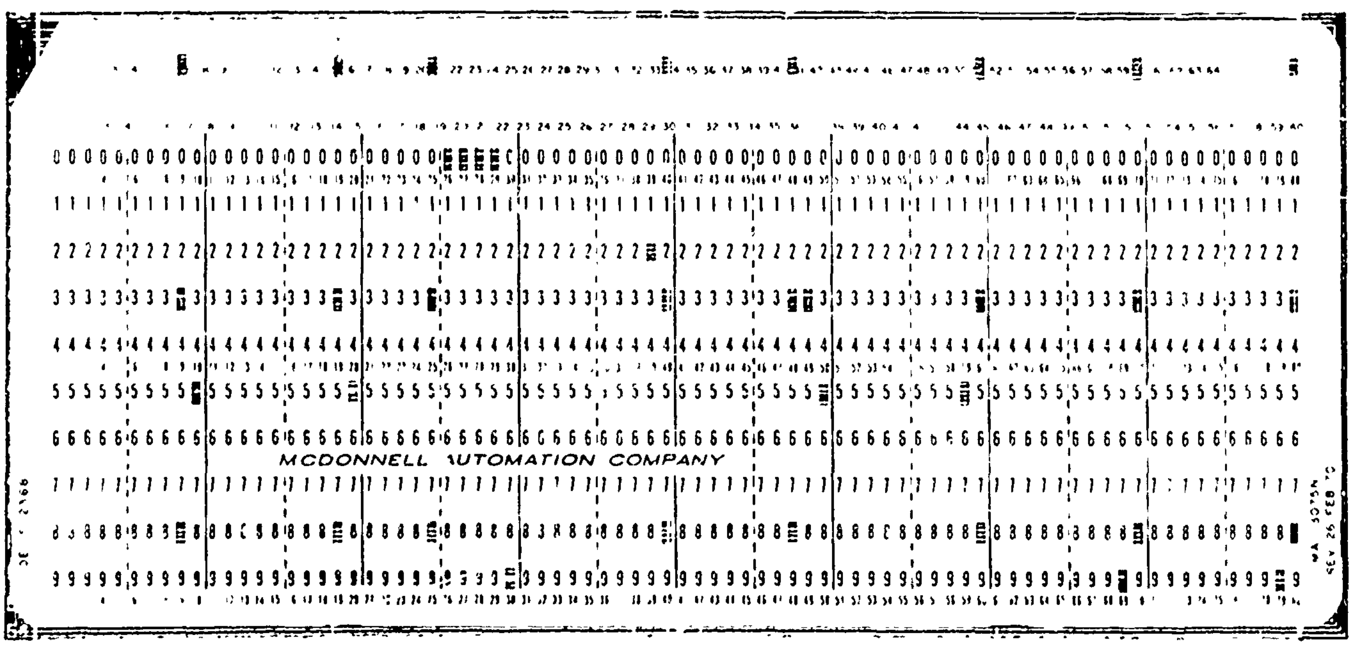


FCVAL31

CARD NUMBER 2

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	INTERNAL DIAMETER OF INLET	IN.
11-20	E10.0	INTERNAL DIAMETER OF OUTLET	IN.
21-30	E10.0	NOT USED	--
31-40	E10.0	SPRING CONSTANT	LB_m/IN.
41-50	E10.0	MAXIMUM POPPET DISPLACEMENT	IN.
51-60	F10.0	SPRING PRELOAD	LB_m.
61-70	E10.0	VALVE MATERIAL TYPE	--
71-80	E10.0	POPPET MATERIAL TYPE	--

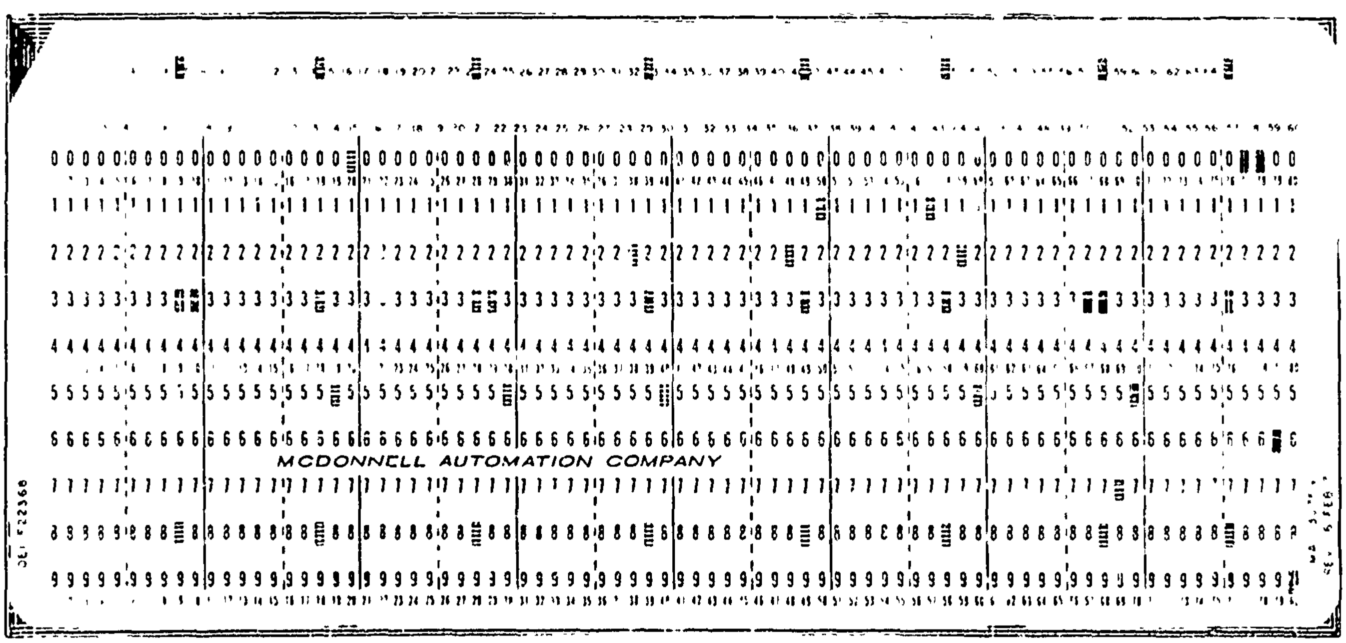
EXAMPLE CARD



CARD NUMBER 3

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	VALVE MASS	LBm
11-20	E10.0	POPPET MASS	LBm
21-30	E10.0	VOLUME OF FLUID INSIDE CHECK VALVE	IN^3
31-40	E10.0	CHECK VALVE LENGTH	IN.
41-50	E10.0	SURFACE AREA FLUID TO PISTON	IN.^{2}
51-60	E10.0	SURFACE AREA FLUID TO CHECK VALVE	IN.^{2}
61-70	E10.0	SURFACE AREA CHECK VALVE TO ATMOSPHERE	IN.^{2}
71-80	E10.0	HEAT TRANSFER COEFF. VALVE TO ATMOSPHERE	WATTS/IN^2-°F

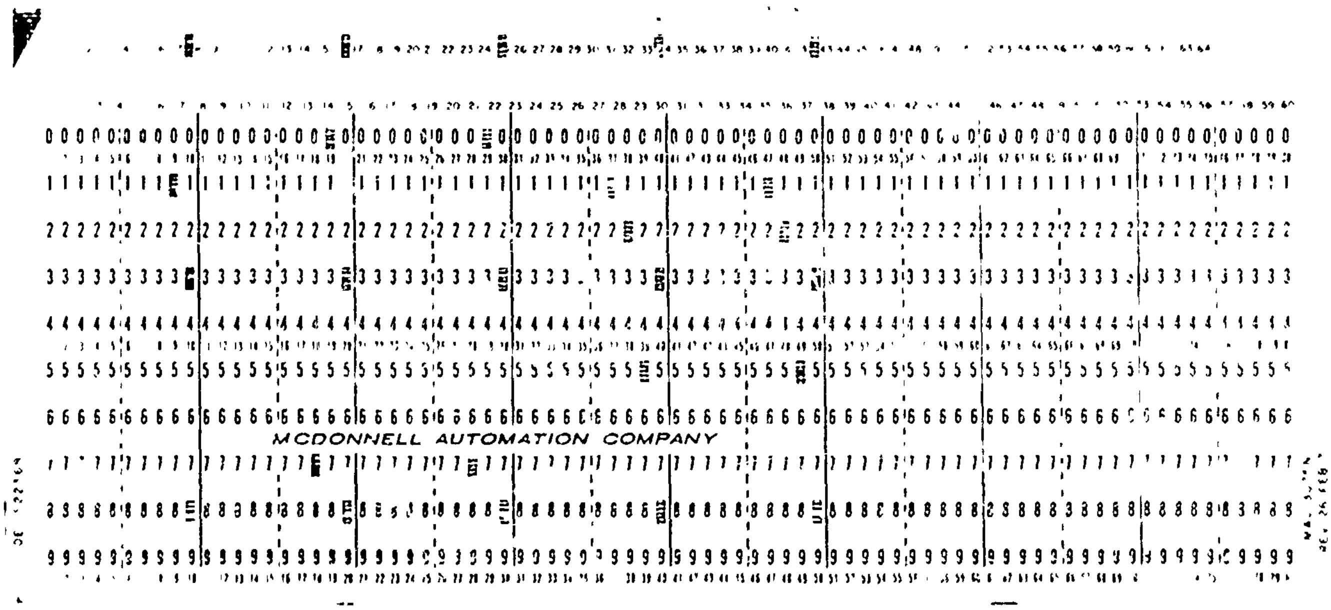
EXAMPLE CARD



CARD NUMBER 4

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	PERCENTAGE HEAT ADDED TO FLUID (DUE TO ΔP)	--
11-20	E10.0	SURROUNDING STRUCTURE TEMPERATURE	°F
21-30	E10.0	SURROUNDING ATMOSPHERE TEMPERATURE	°F
31-40	E10.0	INITIAL TEMPERATURE OF THE FLUID	°F
41-50	E10.0	INITIAL TEMPERATURE OF THE VALVE WALLS	°F
51-60	E10.0		
61-70	E10.0		
71-80	E10.0		

EXAMPLE CARD



6.40 RESTRICTOR

There are several varieties of restrictors, including the simple orifice, Lee Jet and two way ones. The following is currently included in the program.

TYPE #41 Orifice Restrictor (TREST41)

6.41 TYPE #41 ORIFICE RESTRICTORS

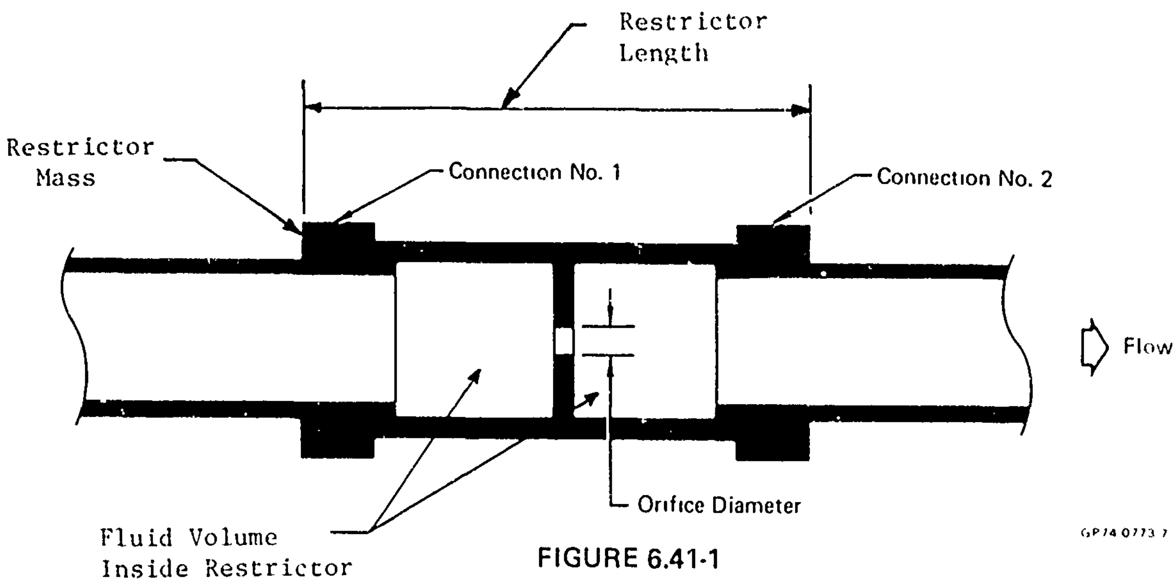


FIGURE 6.41-1
TYPE NO. 41 ORIFICE RESTRICTOR

Type #41 orifice restrictor is a two-way restrictor since for either flow direction the discharge coefficient is assumed to be the same.

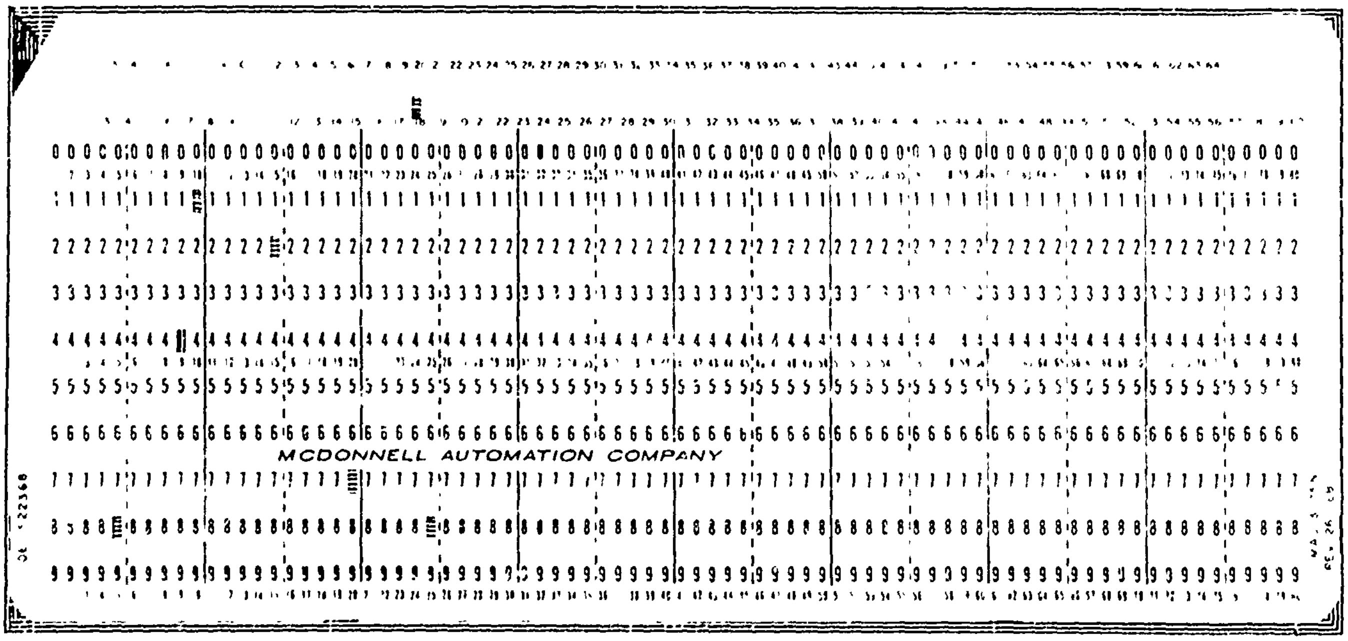
The restrictor fluid and wall temperatures are calculated.

TREST41

CARD NUMBER 1

COLUMN	FORMAT	DATA
1-5	I5	Component Number
6-10	I5	Type Number = 41
11-15	I5	Number of Real Data Cards = 2
16-20	I5	Line Number (with sign) attached to Connection 1
21-25	I5	Line Number (with sign) attached to Connection 2
26-30	I5	
31-35	I5	
36-40	I5	
41-45	I5	
46-50	I5	
51-55	I5	
56-60	I5	
61-65	I5	
66-70	I5	
71-75	I5	
76-80	I5	

EXAMPLE CARD

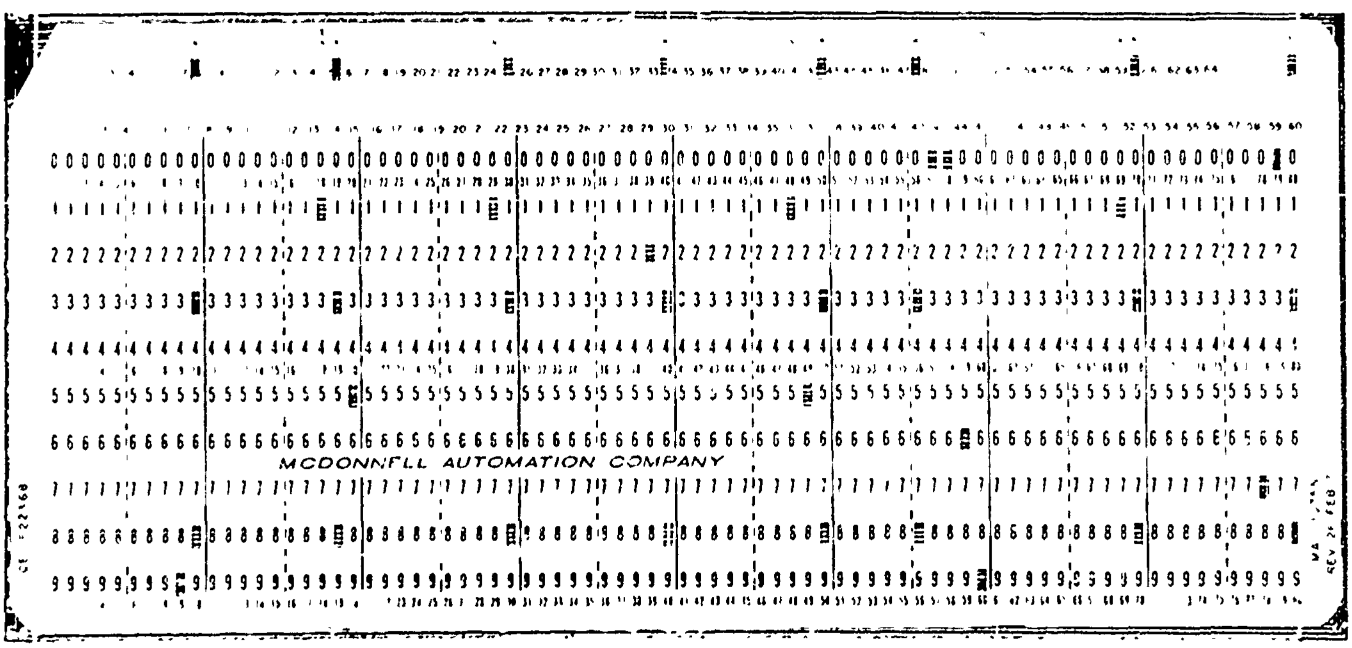


TREST41

CARD NUMBER 2

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	RESTRICTOR MATERIAL TYPE	--
11-20	E10.0	RESTRICTOR MASS	LBm
21-30	E10.0	FLUID VOLUME INSIDE RESTRICTOR	IN.^{3}
31-40	E10.0	RESTRICTOR LENGTH	IN.
41-50	E10.0	SURFACE AREA RESTRICTOR WALL TO ATMOSPHERE	IN.^{2}
51-60	E10.0	HEAT TRANSFER COEFF RESTRICTOR WALL TO ATMOSPHERE	WATTS/IN^2-°F
61-70	E10.0	PERCENTAGE HEAT ADDED TO FLUID (DUE TO P)	--
71-80	E10.0	TEMPERATURE OF SURROUNDING STRUCTURE	°F

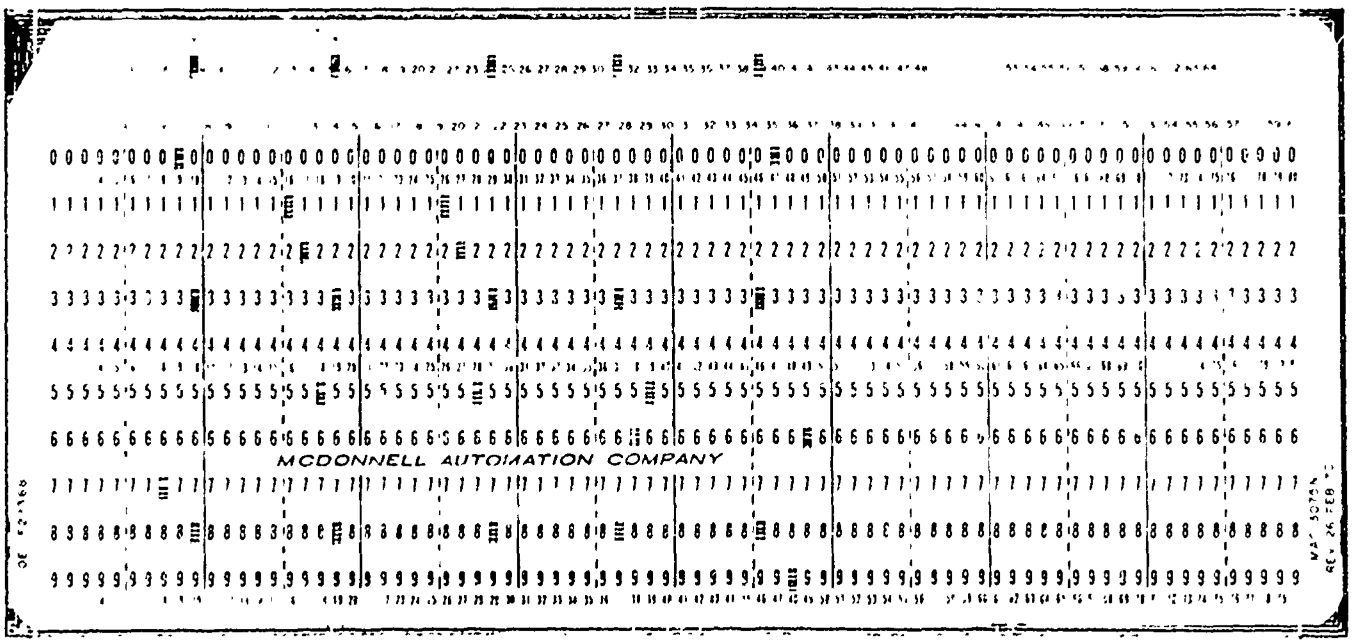
EXAMPLE CARD



CARD NUMBER 3

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	TEMP. OF SURROUNDING ATMOSPHERE	°F
11-20	E10.0	INITIAL TEMPERATURE OF FLUID	°F
21-30	E10.0	INITIAL TEMPERATURE OF RESTRICTOR WALLS	°F
31-40	E10.0	DISCHARGE COEFF.	--
41-50	E10.0	DIAMETER OF THE ORIFICE	IN.
51-60	E10.0		
61-70	E10.0		
71-80	E10.0		

EXAMPLE CARD



6.51 TYPE #51 - PUMP

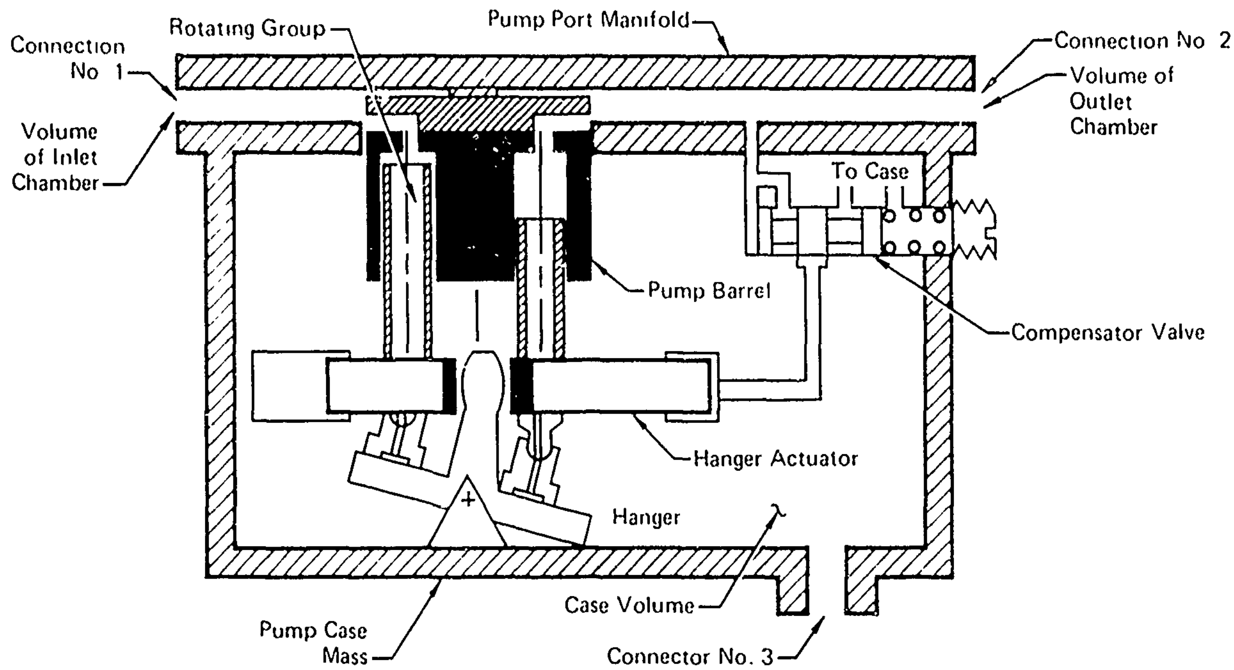


FIGURE 6.51-1
TYPE NO. 51 PRESSURE REGULATED VARIABLE DISPLACEMENT PUMP

GP77 0065 19

The pump subroutine TPUMP51 is a simulation of a pressure regulated variable displacement pump. The pump model computes values of outlet and case drain flows and pressures.

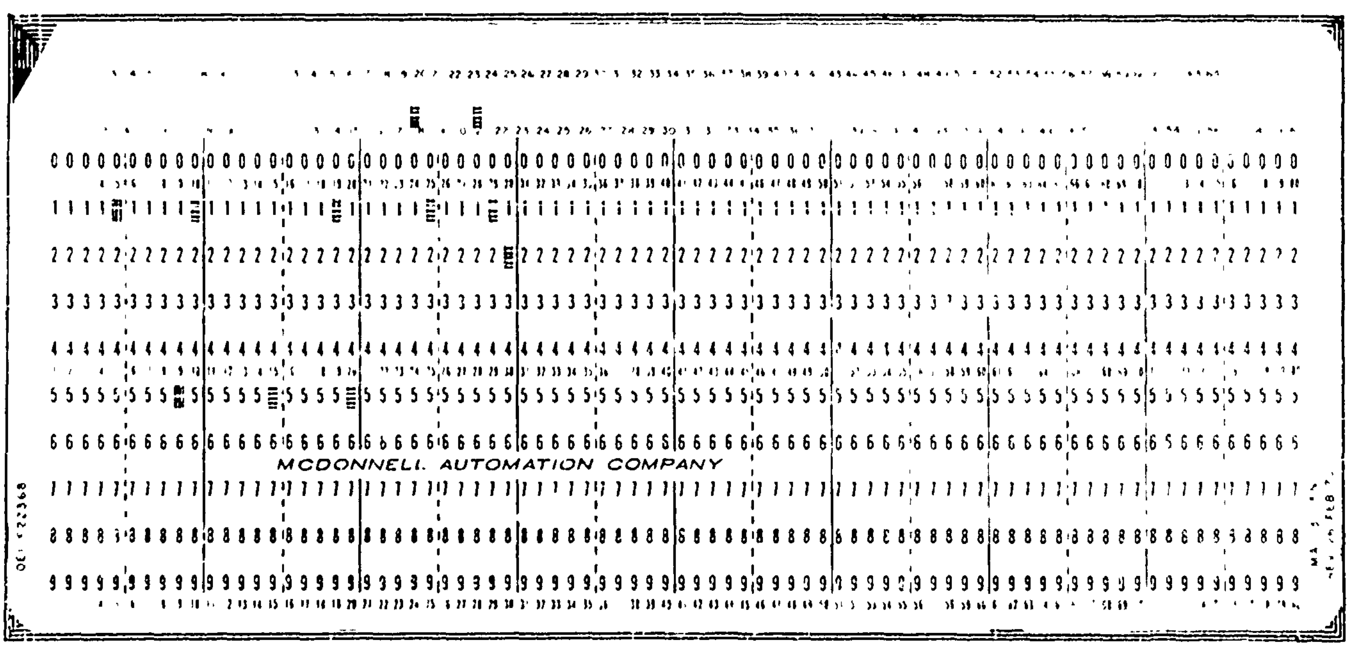
In the thermal model large masses have been grouped together to simpiifv the simulation. Three large masses are used, the internal moving parts, the walls of the pump around the case volume, and the pump wall at the port manifold. The calculated variables are the rotating group and case temperatures, and three fluid temperatures; the exit fluid, the case drain fluid, and the inlet fluid.

TPUMP51

CARD NUMBER 1

COLUMN	FORMAT	DATA
1-5	I5	Component Number
6-10	I5	Type Number = 51
11-15	I5	Number of Real Data Cards = 4
16-20	I5	Line Number (with sign) attached to Connection 1
21-25	I5	Line Number (with sign) attached to Connection 2
26-30	I5	Line Number (with sign) attached to Connection 3
31-35	I5	
36-40	I5	
41-45	I5	
46-50	I5	
51-55	I5	
56-60	I5	
61-65	I5	
66-70	I5	
71-75	I5	
76-80	I5	

EXAMPLE CARD

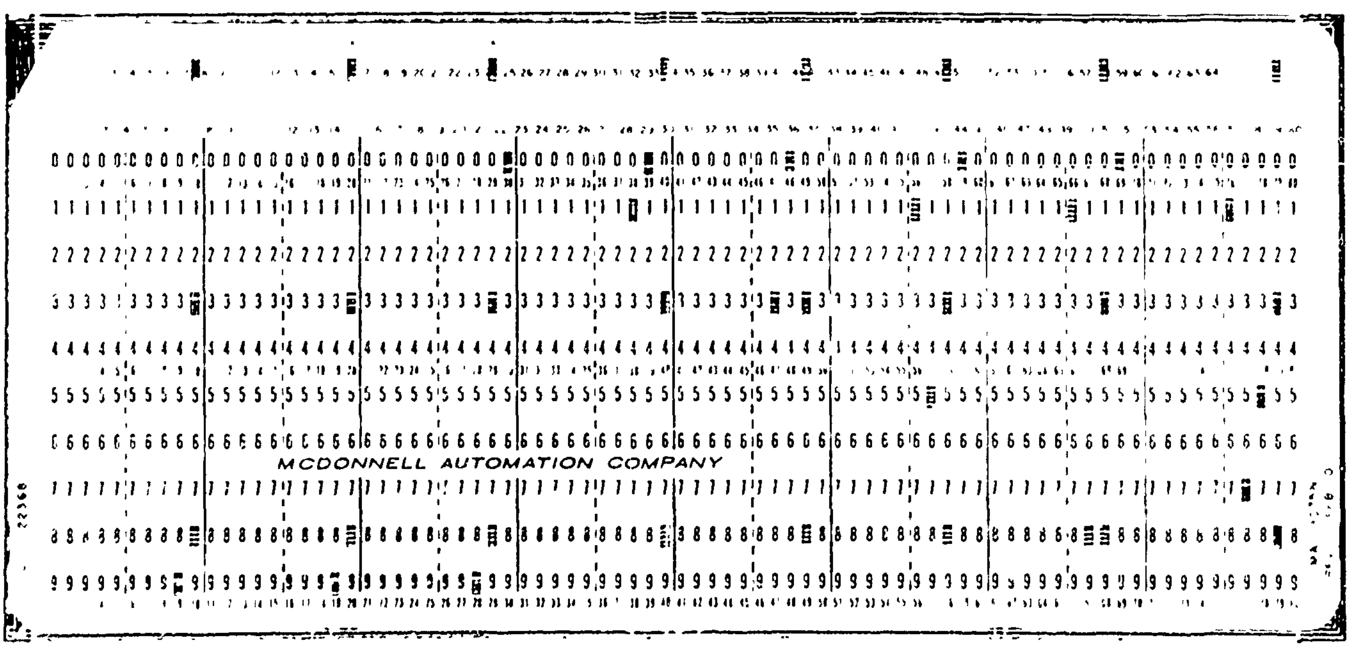


CARD NUMBER 2

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	PUMP WALLS MATERIAL TYPE	--
11-20	E10.0	ROTATING GROUP* MATERIAL TYPE	--
21-30	E10.0	PUMP PORT MANIFOLD MASS (SURROUNDING VOL 1&VOL2)	LBm
31-40	E10.0	ROTATING GROUP MASS*	LBm
41-50	E10.0	PUMP CASE MASS	LBm
51-60	E10.0	PUMP INLET VOLUME	IN.^{3}
61-70	E10.0	PUMP OUTLET VOLUME	IN.^{3}
71-80	E10.0	PUMP CASE VOLUME	IN.^{3}

* The rotating group consists of all moving parts, as the pistons, yoke, drive shaft, etc.

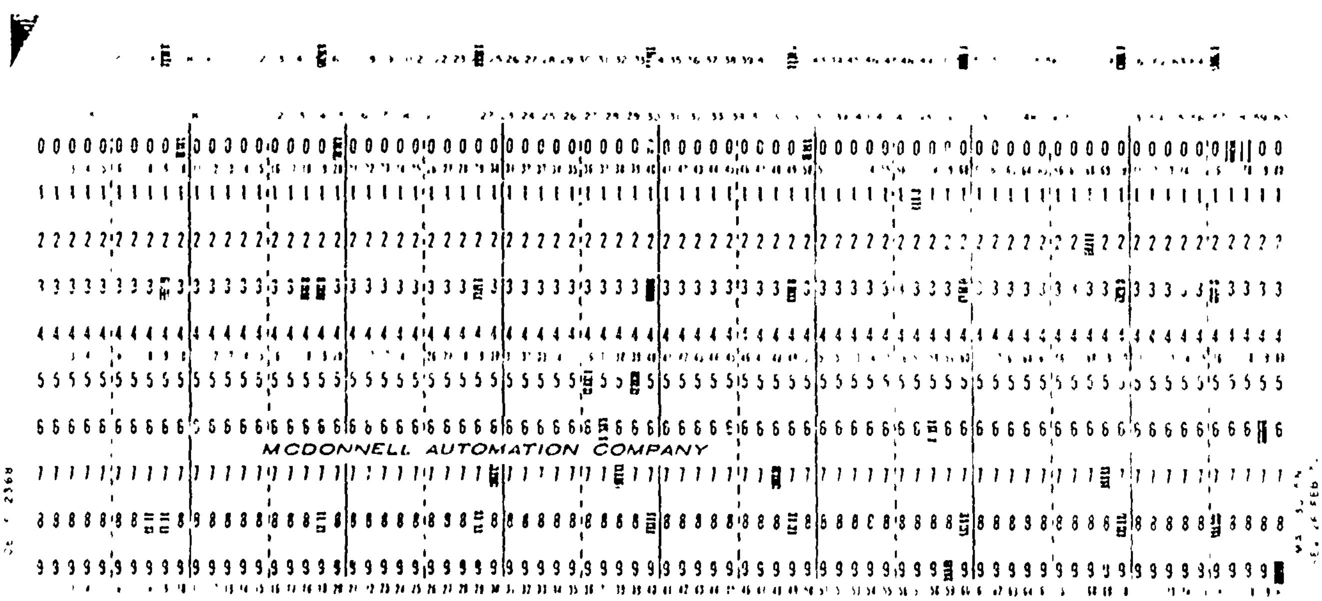
EXAMPLE CARD



CARD NUMBER 3

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	AVERAGE CROSS SECTIONAL AREA OF THE ROTATING GROUP	$IN.^2$
11-20	E10.0	CONTACT AREA BETWEEN THE ROTATING GROUP AND THE PUMP WALLS	$IN.^2$
21-30	E10.0	HEAT TRANSFER COEFFICIENT BETWEEN EXIT FLUID AND ROTATING GROUP	$WATTS/IN^2$-°F
31-40	E10.0	HEAT REJECTION AT RATED FLOW	WATTS
41-50	E10.0	DISTANCE FROM INLET TO OUTLET THRU PORT PLATE	IN.
51-60	F10.0	EXTERNAL SURFACE AREA OF PUMP PORT MANIFOLD	$IN.^2$
61-70	E10.0	EXTERNAL SURFACE AREA OF PUMP CASE	$IN.^2$
71-80	E10.0	HEAT TRANSFER, COEFF. FROM ATMOSPHERE TO PUMP CASE	$WATTS/IN^2$-°F

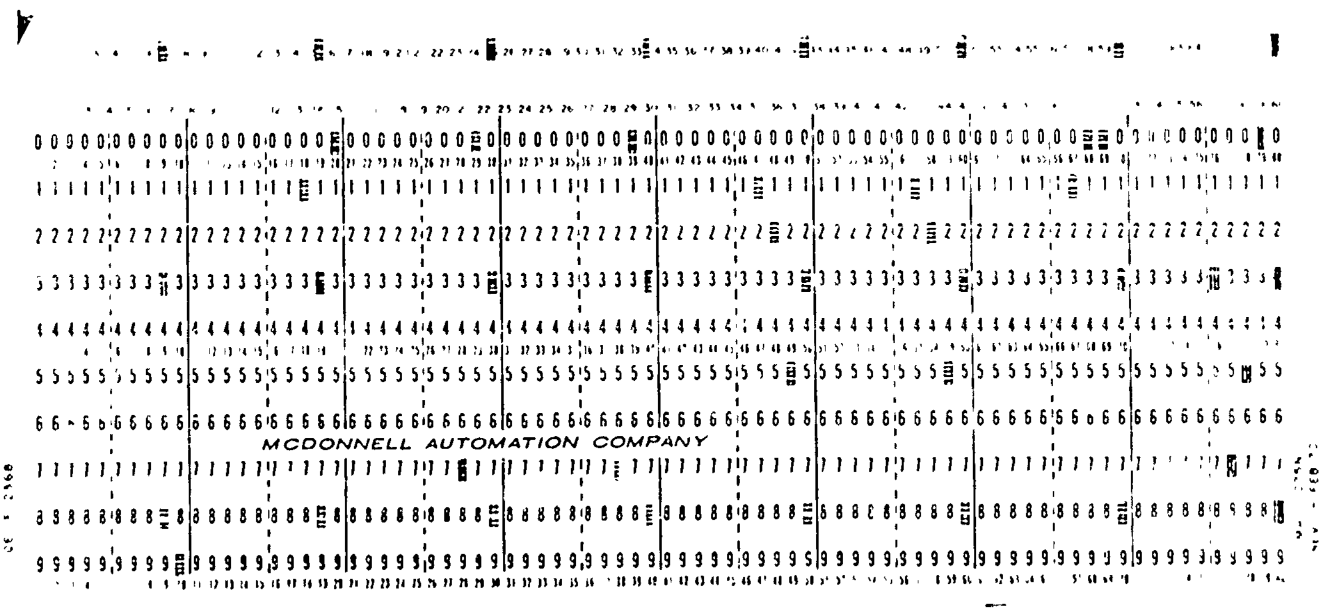
EXAMPLE CARD



CARD NUMBER 4

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	INTERFACE CONDUCTANCE BETWEEN THE CASE AND THE ROTATING GROUP	WATTS/IN^2-°F
11-20	E10.0	HEAT TRANSFER COEFF., INLET FLUID TO MANIFOLD WALLS	WATTS/IN^2-°F
21-30	E10.0	SURROUNDING STRUCTURE TEMPERATURE	°F
31-40	E10.0	SURROUNDING ATMOSPHERIC TEMPERATURE	°F
41-50	E10.0	INITIAL TEMPERATURE OF THE FLUID	°F
51-60	F10.0	INITIAL TEMPERATURE OF THE WALLS	°F
61-70	E10.0	RATED FLOW	CIS
71-80	E10.0	PUMP RPM AT RATED FLOW	RPM

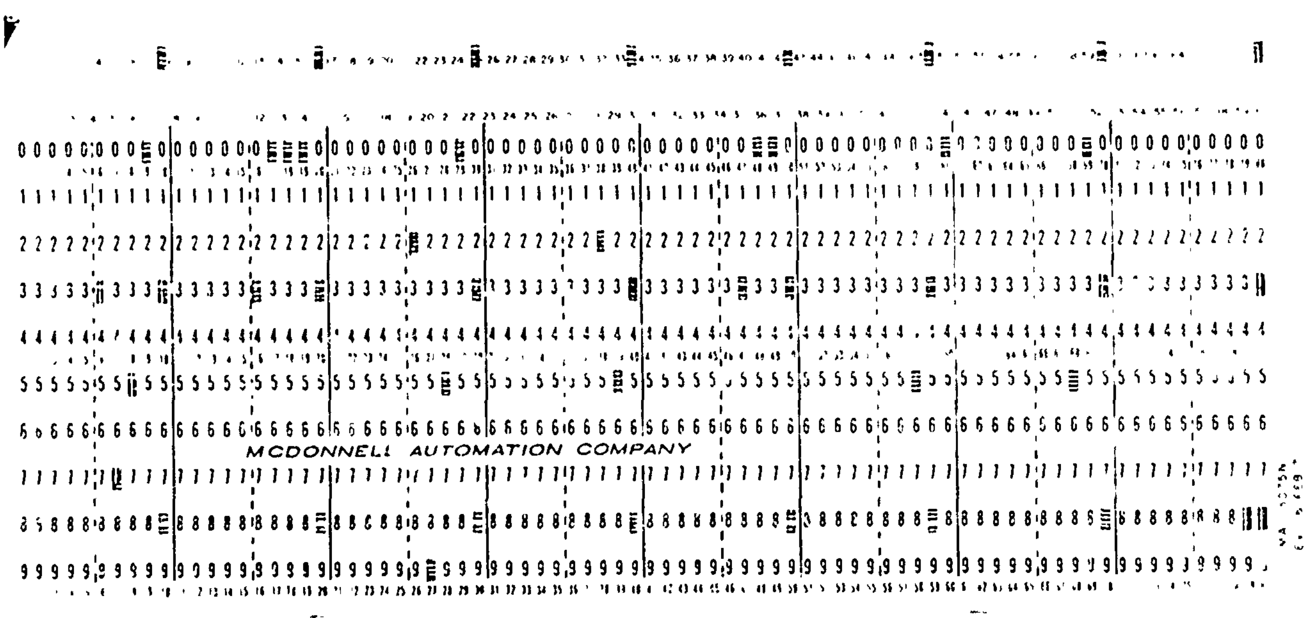
EXAMPLE CARD



CARD NUMBER 5

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	PUMP SPEED	RPM
11-20	E10.0	RATED OUTPUT PRESSURE AT ZERO FLOW	PSI
21-30	E10.0	RATED OUTPUT PRESSURE AT FULL FLOW	PSI
31-40	E10.0	MINIMUM INLET PRESSURE	PSI
41-50	E10.0	MAXIMUM PRESSURE DIFFERENCE BETWEEN PUMP CASE AND INLET	PSID
51-60	E10.0	CASE FLOW AT RATED FLOW AND PRESSURE	CIS
61-70	E10.0	CASE PRESSURE AT RATED FLOW AND PRESSURE	PSI
71-30	E10.0	DEPTH OF PUMP CASE	IN

EXAMPLE CARD



6.60 RESERVOIRS/HEAT EXCHANGERS

There are a number of types of reservoirs which need different methods of analysis. Among these are, constant pressure reservoir, bootstrap reservoir, trapped bootstrap reservoir and reservoir with RLS and bootstrap. The following types are currently included in the program:

Type #61	Constant Pressure Reservoir (TRSVR61)
Type #62	Bootstrap Reservoir (TRSVR62)
Type #69	Heat Exchanger (THEX69)

6.61 TYPE #61 CONSTANT PRESSURE RESERVOIR

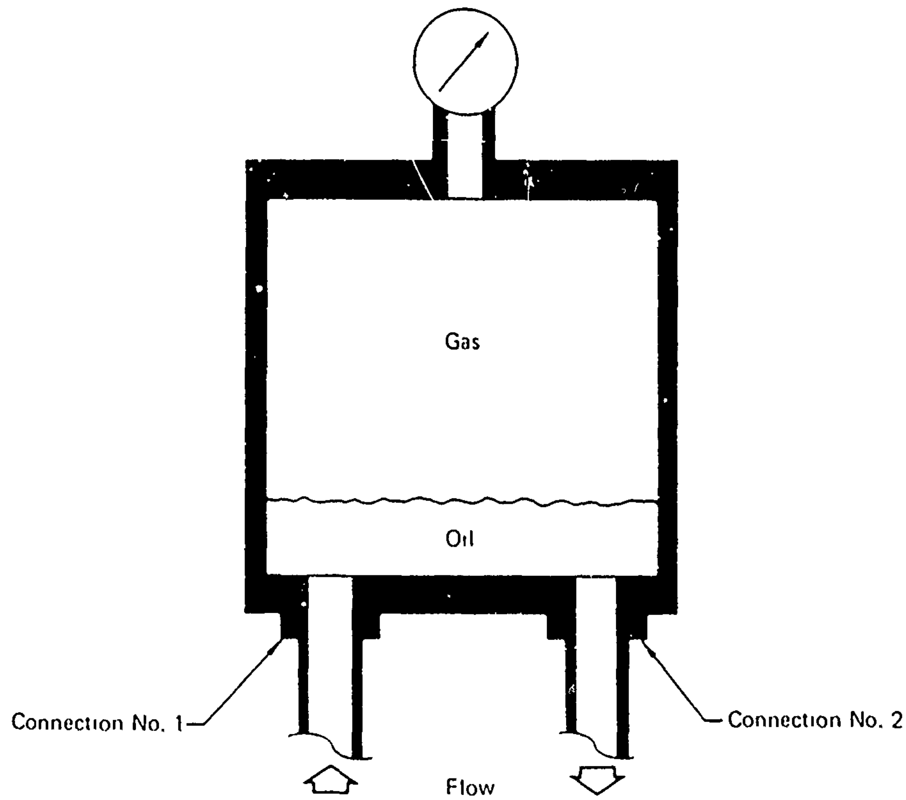


FIGURE 6.61-1
TYPE NO. 61 CONSTANT PRESSURE RESERVOIR

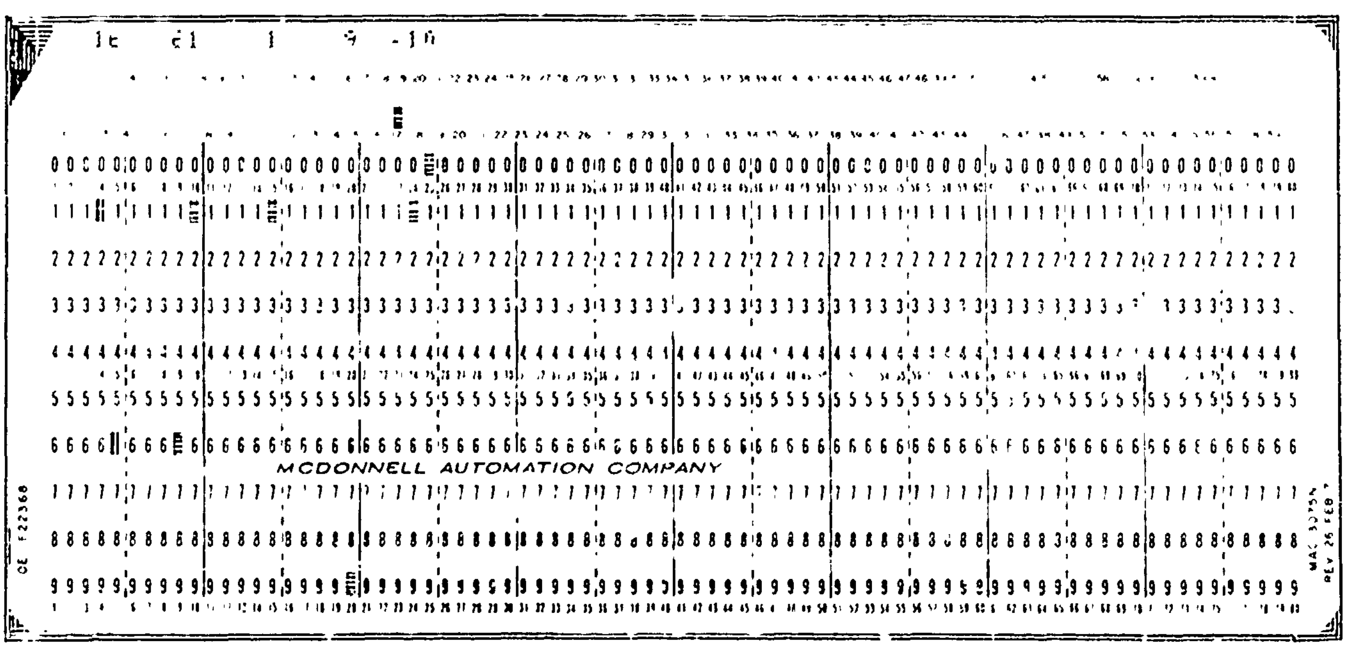
The Type #61 cons - pressure reservoir which is used for test simulation purposes, requires only the connection information the reservoir pressure, fluid and wall temperatures. Any of the four connections not used are blanked off. The temperatures are considered to be constant.

TRSVR61

CARD NUMBER 1

COLUMN	FORMAT	DATA
1-5	I5	Component Number
6-10	I5	Type Number = 61
11-15	I5	Number of Real Data Cards = 1
16-20	I5	Line Number (with sign) attached to Connection 1
21-25	I5	Line Number (with sign) attached to Connection 2
26-30	I5	Line Number (with sign) attached to Connection 3
31-35	I5	Line Number (with sign) attached to Connection 4
36-40	I5	
41-45	I5	
46-50	I5	
51-55	I5	
56-60	I5	
61-65	I5	
66-70	I5	
71-75	I5	
76-80	I5	

EXAMPLE CARD

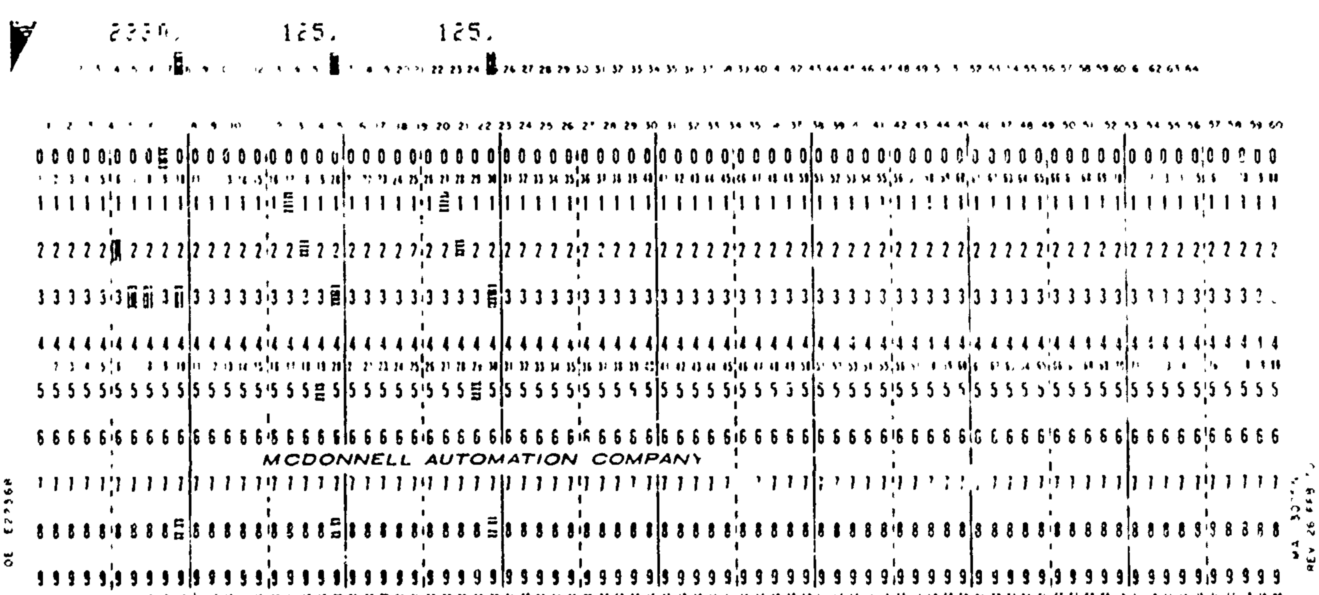


TRSVRC1

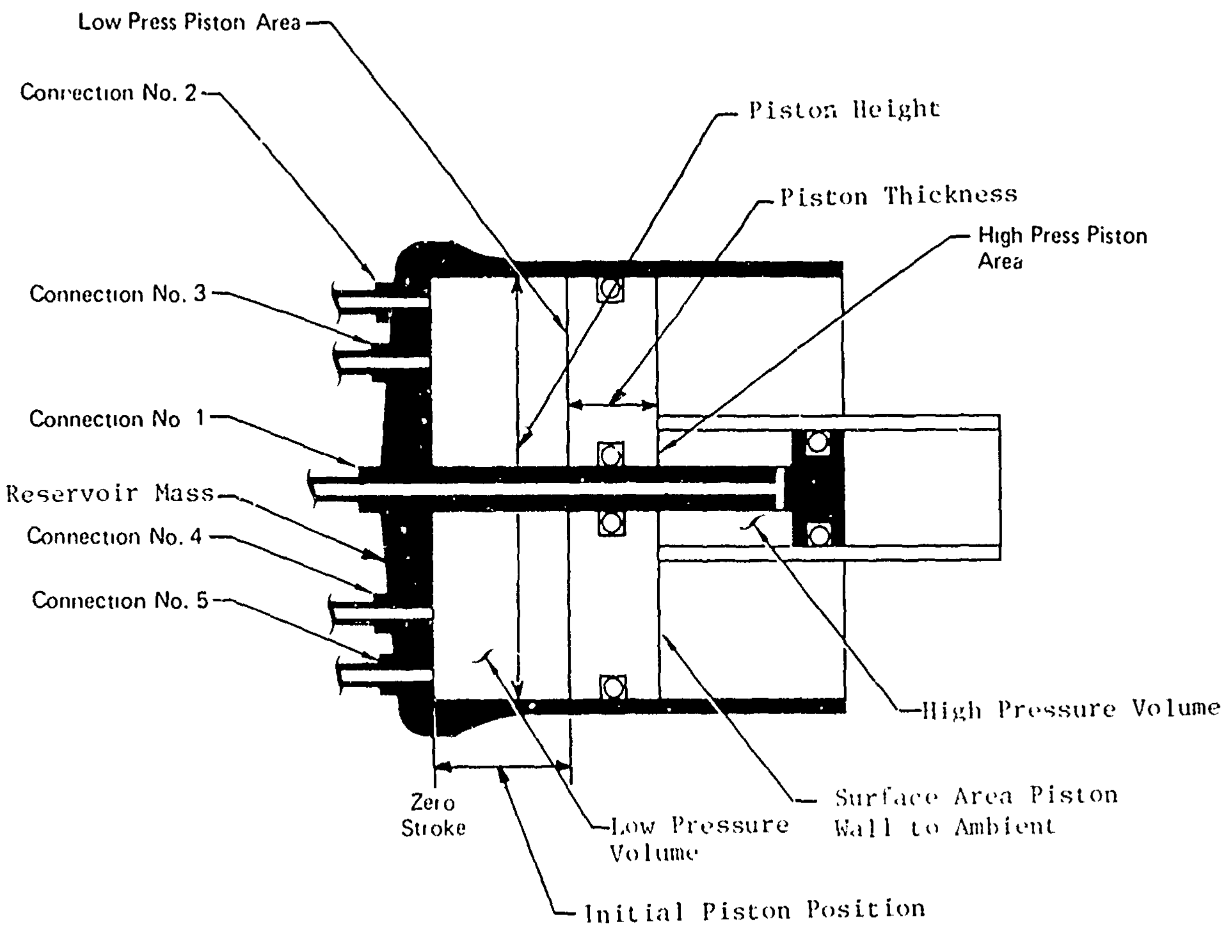
CARD NUMBER 2

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	Reservoir Pressure	PSI
11-20	E10.0	Fluid Temperature	°F
21-30	E10.0	Wall Temperature	°F
31-40	E10.0		
41-50	E10.0		
51-60	E10.0		
61-70	E10.0		
71-80	E10.0		

EXAMPLE CARD



6.62 TYPE #62 BOOTSTRAP RESERVOIR



TYPE NO. 62 BOOTSTRAP RESERVOIR

FIGURE 6.62-1

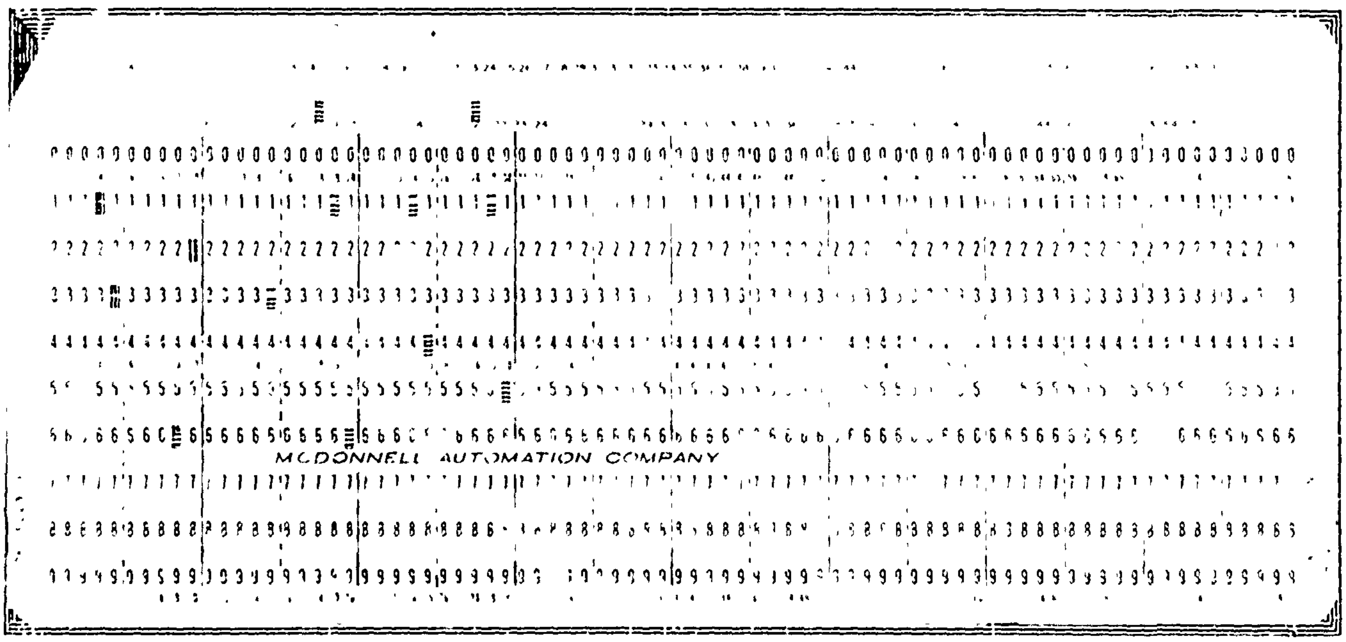
The Type #62 bootstrap reservoir is the type used on various aircraft. As many as four low pressure connections can be used plus the high pressure connection. Any low pressure connection(s) not required is to be left blank. The reservoir fluid temperature, wall, and piston temperatures are the calculated values.

TRSVR62

CARD NUMBER 1

COLUMN	FORMAT	DATA
1-5	I5	Component Number
6-10	I5	Type Number = 62
11-15	I5	Number of Real Data Cards = 3
16-20	I5	Line Number (with sign) attached to Connection 1
21-25	I5	Line Number (with sign) attached to Connection 2
26-30	I5	Line Number (with sign) attached to Connection 3
31-35	I5	Line Number (with sign) attached to Connection 4
36-40	I5	Line Number (with sign) attached to Connection 5
41-45	I5	
46-50	I5	
51-55	I5	
56-60	I5	
61-65	I5	
66-70	I5	
71-75	I5	
76-80	I5	

EXAMPLE CARD

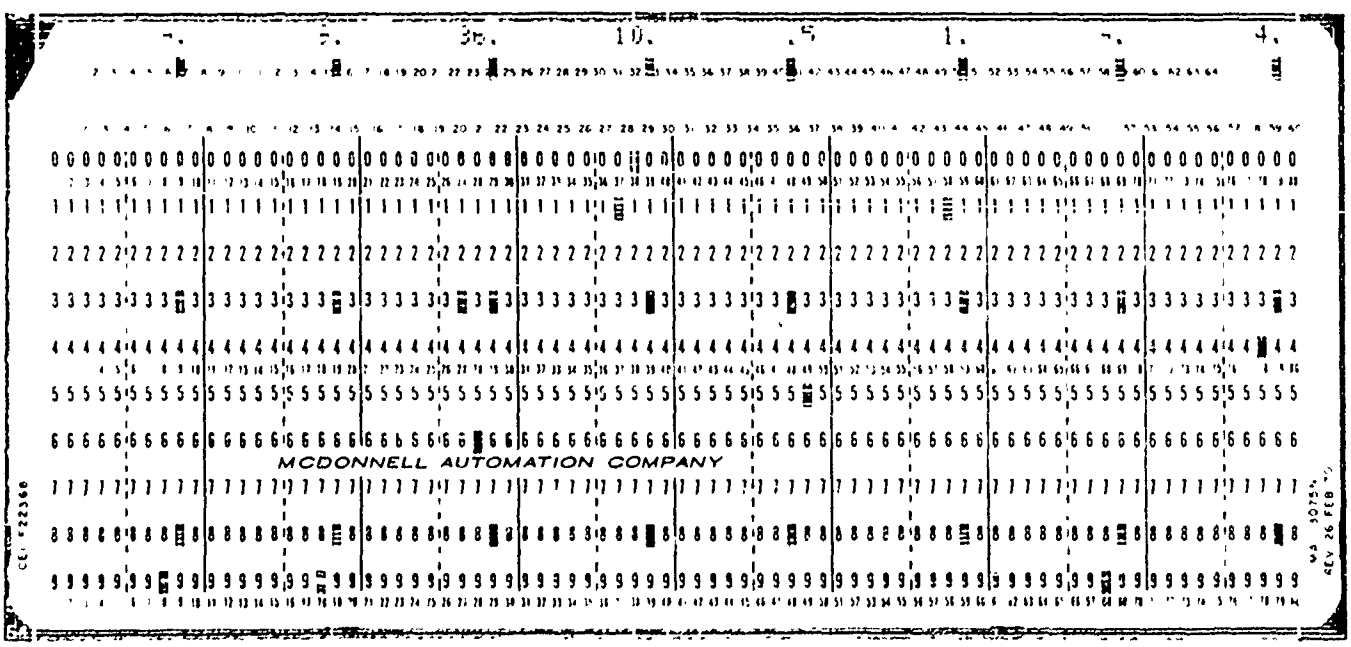


TRSVR62

CARD NUMBER 2

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	RESERVOIR MATERIAL TYPE	--
11-20	E10.0	PISTON MATERIAL TYPE	--
21-30	E10.0	RESERVOIR MASS	LBm
31-40	E10.0	LOW PRESSURE PISTON AREA	$IN.^2$
41-50	E10.0	HIGH PRESSURE PISTON AREA	$IN.^2$
51-60	E10.0	LOW PRESSURE VOLUME (MINIMUM)	$IN.^3$
61-70	E10.0	HIGH PRESSURE VOLUME (MAXIMUM)	$IN.^3$
71-80	E10.0	INITIAL PISTON POSITION	IN.

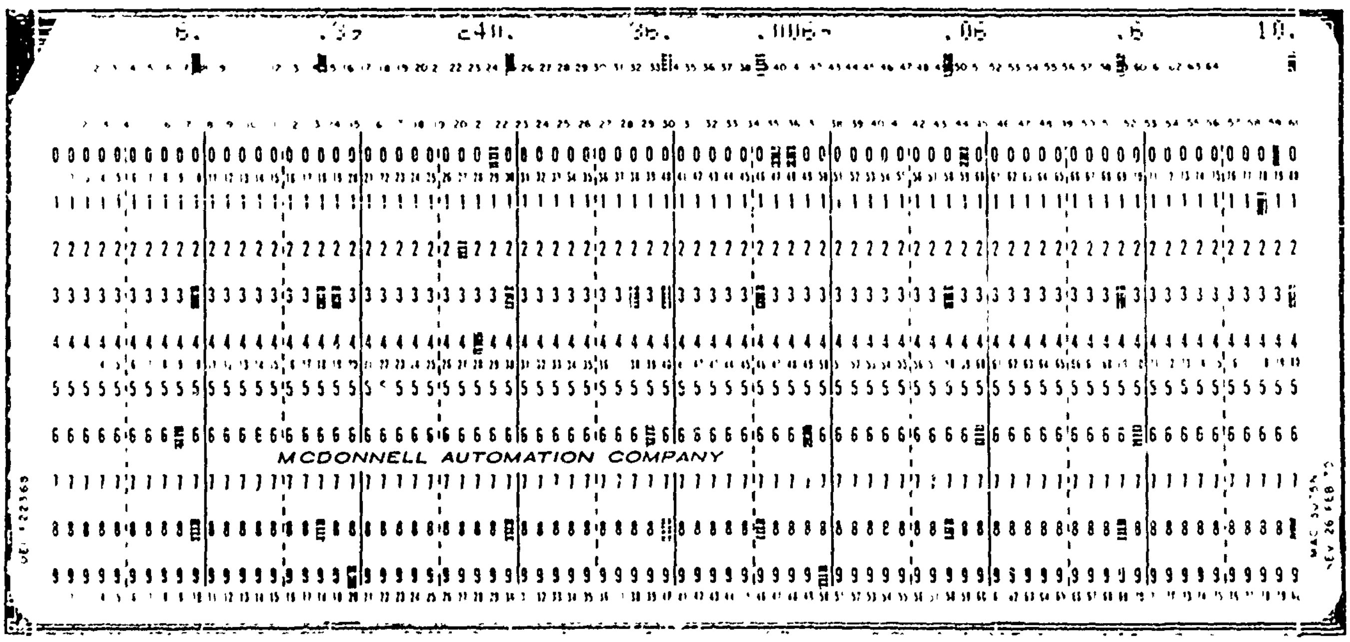
EXAMPLE CARD



CARD NUMBER 3

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	PISTON HEIGHT	IN.
11-20	E10.0	PISTON THICKNESS	IN.
21-30	E10.0	SURFACE AREA RESERVOIR WALLS TO ATMOSPHERE	$IN.^2$
31-40	E10.0	SURFACE AREA PISTON WALL TO ATMOSPHERE	$IN.^2$
41-50	E10.0	HEAT TRANSFER COEFF. WALLS TO ATMOSPHERE	WATTS/IN^2-°F
51-60	E10.0	HEAT TRANSFER COEFF. FLUID TO WALLS (INSIDE)	WATTS/IN^2-°F
61-70	E10.0	PISTON STROKE	IN.
71-80	E10.0	INTERFACE CONDUCTANCE - PISTON TO WALLS	WATTS/IN-°F

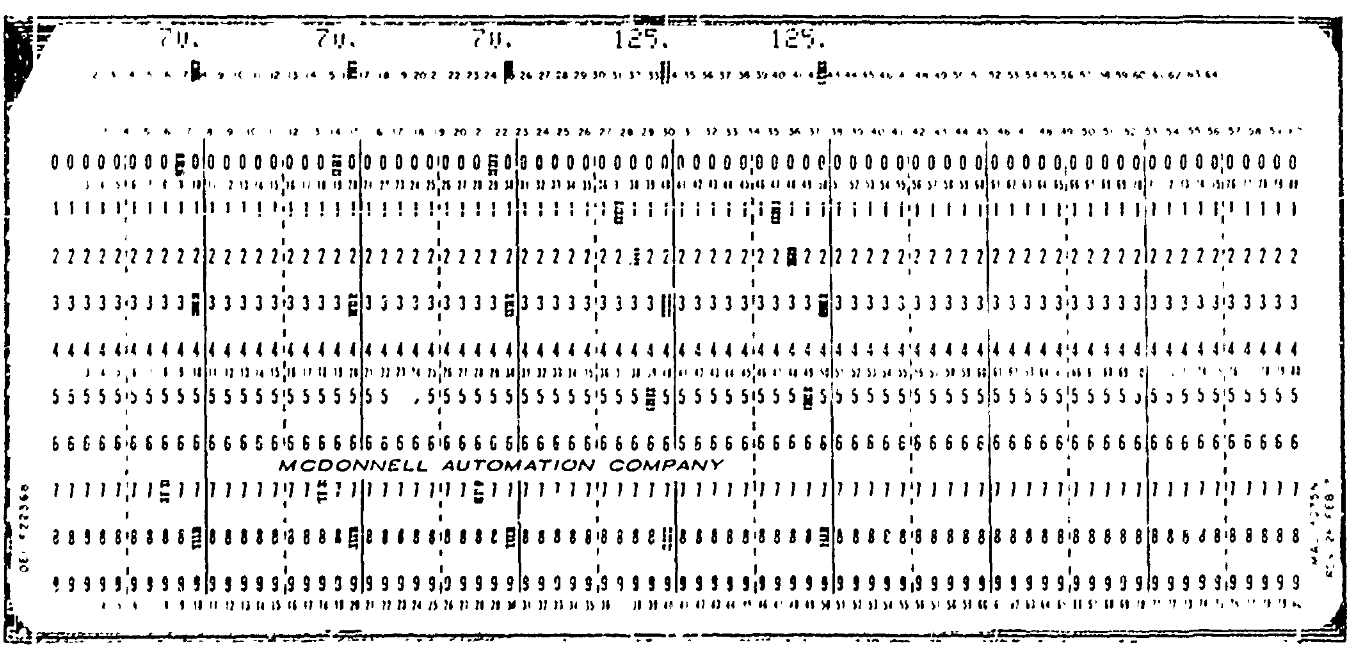
EXAMPLE CARD



CARD NUMBER 4

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	PERCENTAGE HEAT ADDED TO THE FLUID (DUE TO ΔP)	--
11-20	E10.0	SURROUNDING STRUCTURE TEMPERATURE	°F
21-30	E10.0	SURROUNDING ATMOSPHERIC TEMPERATURE	°F
31-40	E10.0	INITIAL TEMPERATURE OF THE FLUID	°F
41-50	E10.0	INITIAL TEMPERATURE OF THE WALLS	°F
51-60	E10.0		
61-70	E10.0		
71-80	E10.0		

EXAMPLE CARD



6.69 TYPE #69 HEAT EXCHANGER

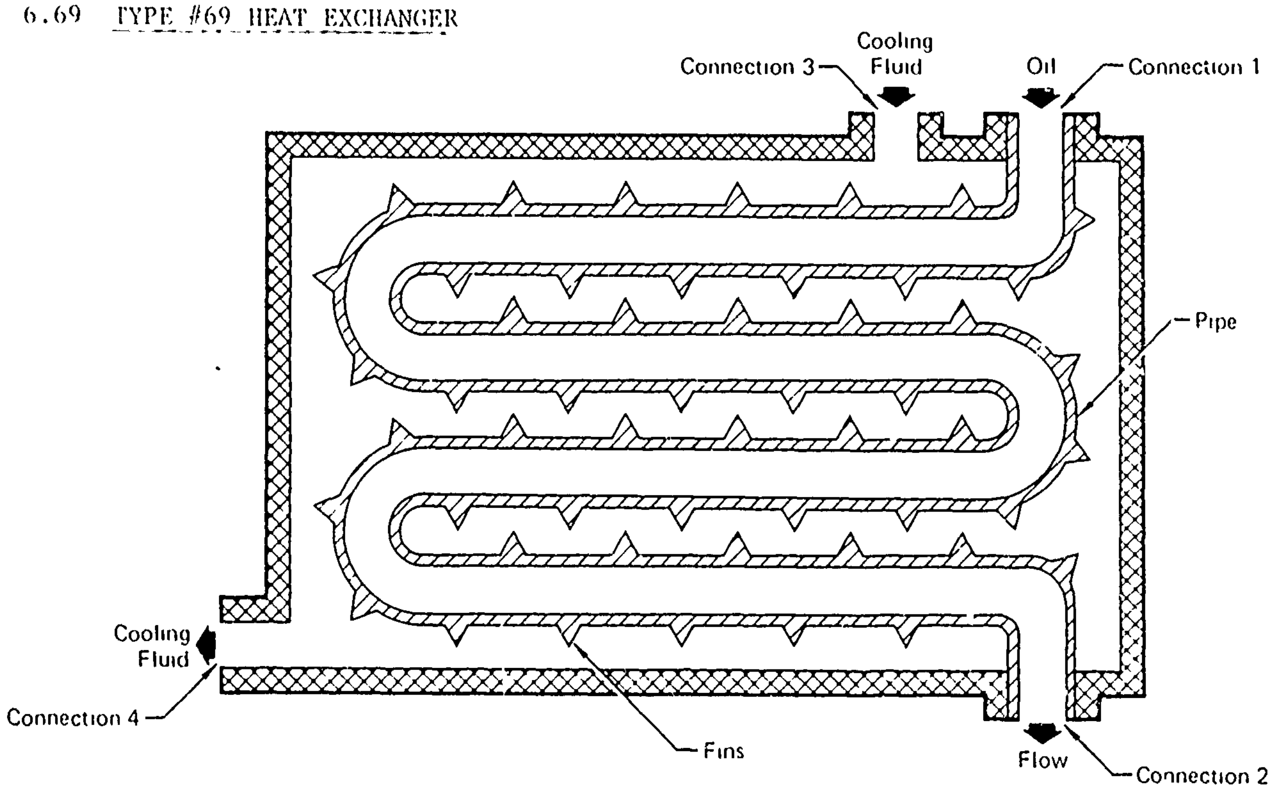


FIGURE 6.69-1
HEAT EXCHANGER

GP77-0065-2

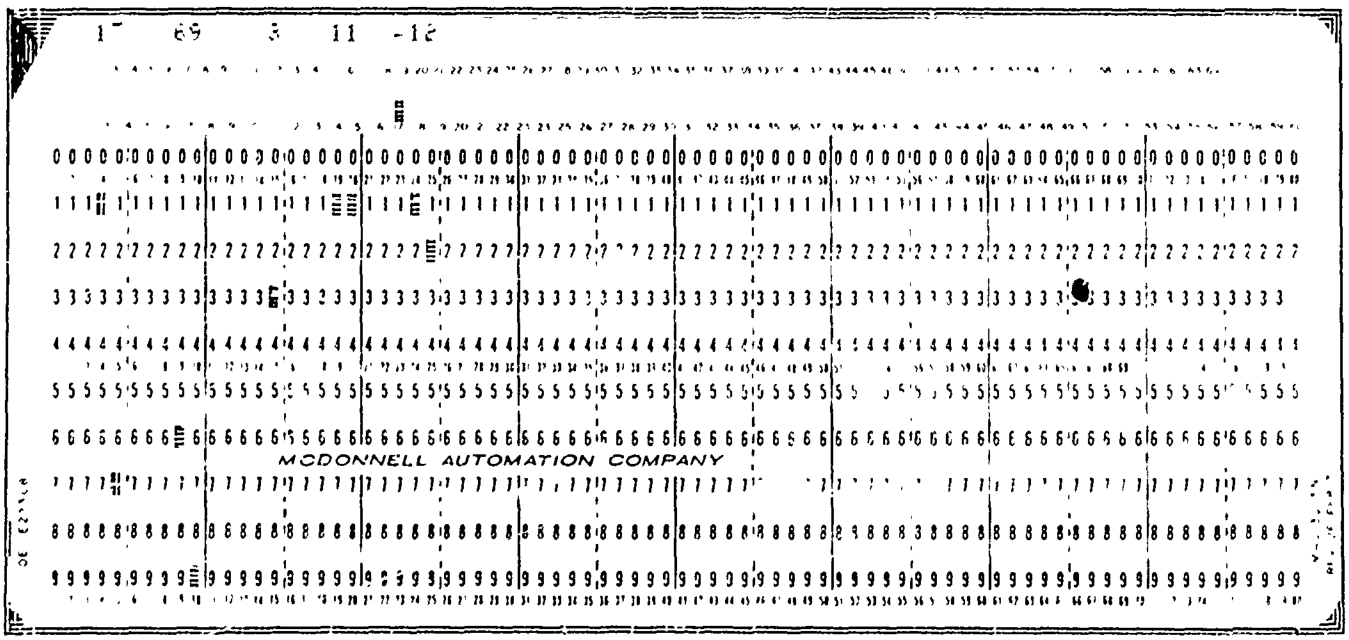
The Type #69 heat exchanger is a type for many basic uses. The inputs are versatile enough to cover most simple heat exchangers since all surface areas are input by the user.

The program computes the heat exchanger fluid temperature, the cooling liquid temperature and the pipe and wall temperatures.

CARD NUMBER 1

COLUMN	FORMAT	DATA
1-5	I5	Component Number
6-10	I5	Type Number = 69
11-15	I5	Number of Real Data Cards = 3
16-20	I5	Line Number (with sign) attached to Connection 1
21-25	I5	Line Number (with sign) attached to Connection 2
26-30	I5	
31-35	I5	
36-40	I5	
41-45	I5	
46-50	I5	
51-55	I5	
56-60	I5	
61-65	I5	
66-70	I5	
71-75	I5	
76-80	I5	

EXAMPLE CARD



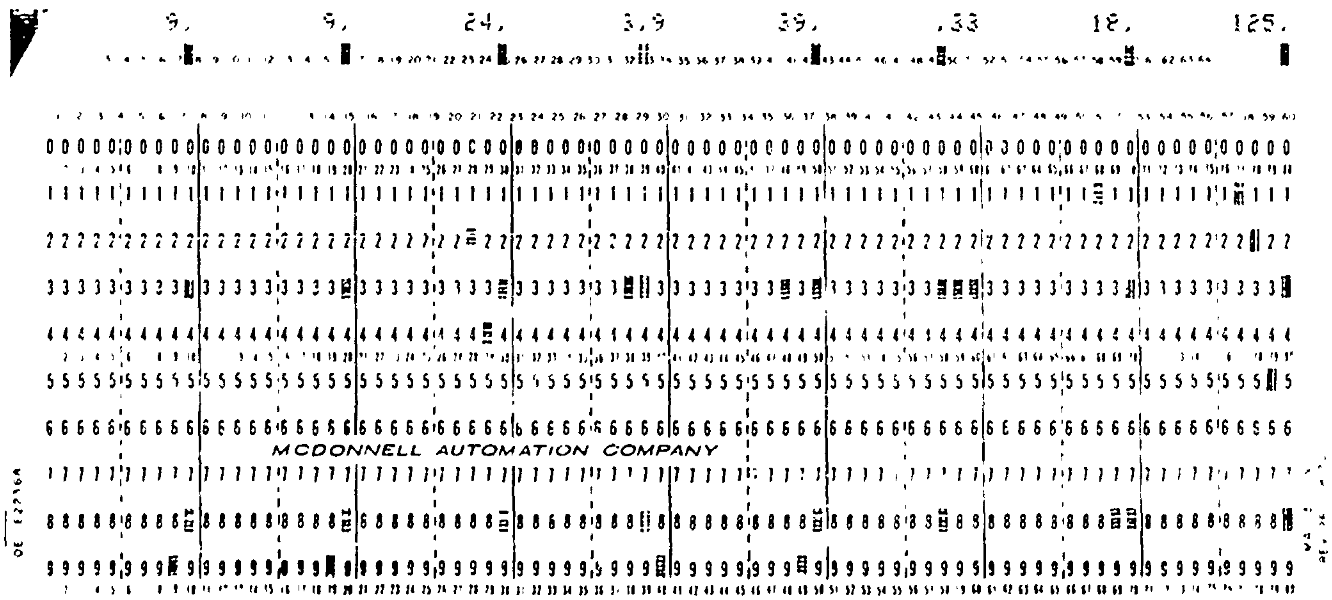
CARD NUMBER 2

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	MATERIAL TYPE OF THE HEAT EXCHANGER	--
11-20	E10.0	COOLING LIQUID TYPE (NOT USED)	--
21-30	E10.0	HEAT EXCHANGER MASS	LBm
31-40	E10.0	MASS OF PIPE WITH FINS	LBm
41-50	E10.0	EXCHANGER PIPE LENGTH *	IN.
51-60	E10.0	INSIDE DIAMETER OF THE PIPE *	IN.
61-70	E10.0	EXCHANGER OVER ALL LENGTH	IN.
71-80	E10.0	VOLUME OF THE COOLING LIQUID IN THE EXCHANGER	$IN.^3$

* If not using a pipe, just fluid paths (fins), the pipe mass is the path walls (fins). The inside diameter and pipe length must be chosen so that the total volume of hydraulic fluid in the exchanger is equivilant to a pipe of that length and inside diameter.

Try to keep inside diameter small and length near to the distance the fluid travels in the exchanger.

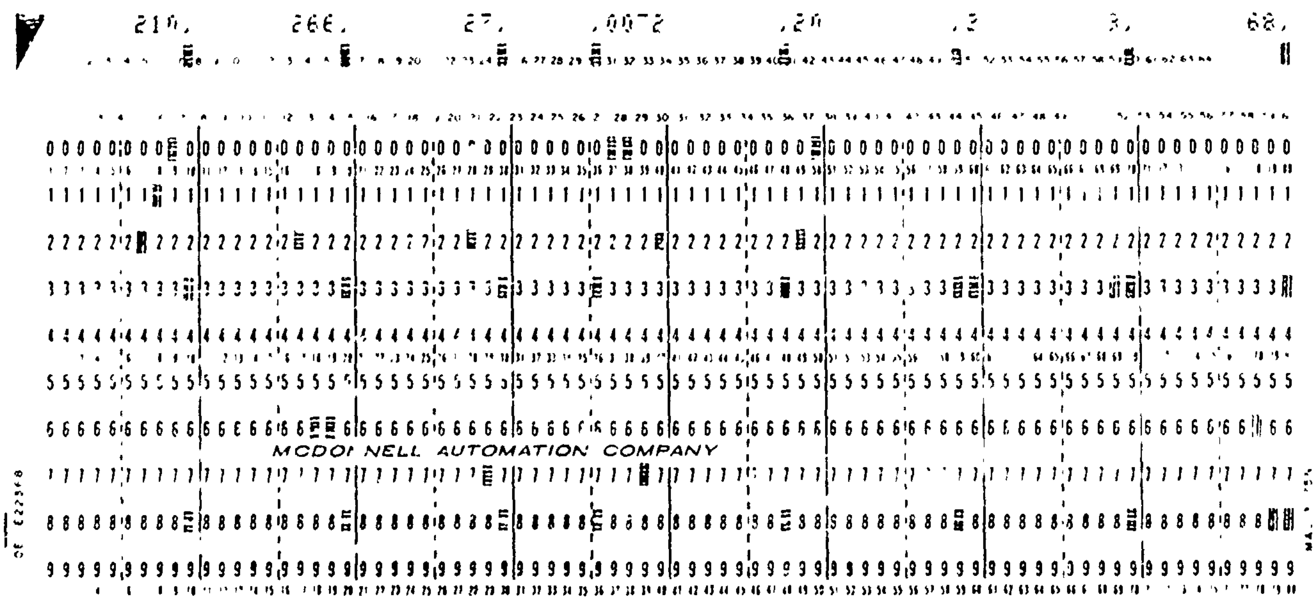
EXAMPLE CARD



CARD NUMBER 3

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	SURFACE AREA WALLS TO COOLING LIQUID	$IN.^2$
11-20	E10.0	SURFACE AREA WALLS TO ATMOSPHERE	$IN.^2$
21-30	E10.0	SURFACE AREA PIPE OR FINS TO COOLING LIQUID	$IN.^2$
31-40	E10.0	HEAT TRANSFER COEFF. WALLS TO ATMOSPHERE	$WATTS/IN^2$-°F
41-50	E10.0	HEAT TRANSFER COEFF. WALLS TO COOLING LIQUID	$WATTS/IN^2$-°F
51-60	E10.0	HEAT TRANSFER COEFF. PIPE TO COOLING LIQUID	$WATTS/IN^2$-°F
61-70	E10.0	MASS FLOW RATE OF THE COOLING LIQUID	LBm/SEC.
71-80	E10.0	INLET TEMPERATURE OF THE COOLING LIQUID	°F

EXAMPLE CARD



CARD NUMBER 4

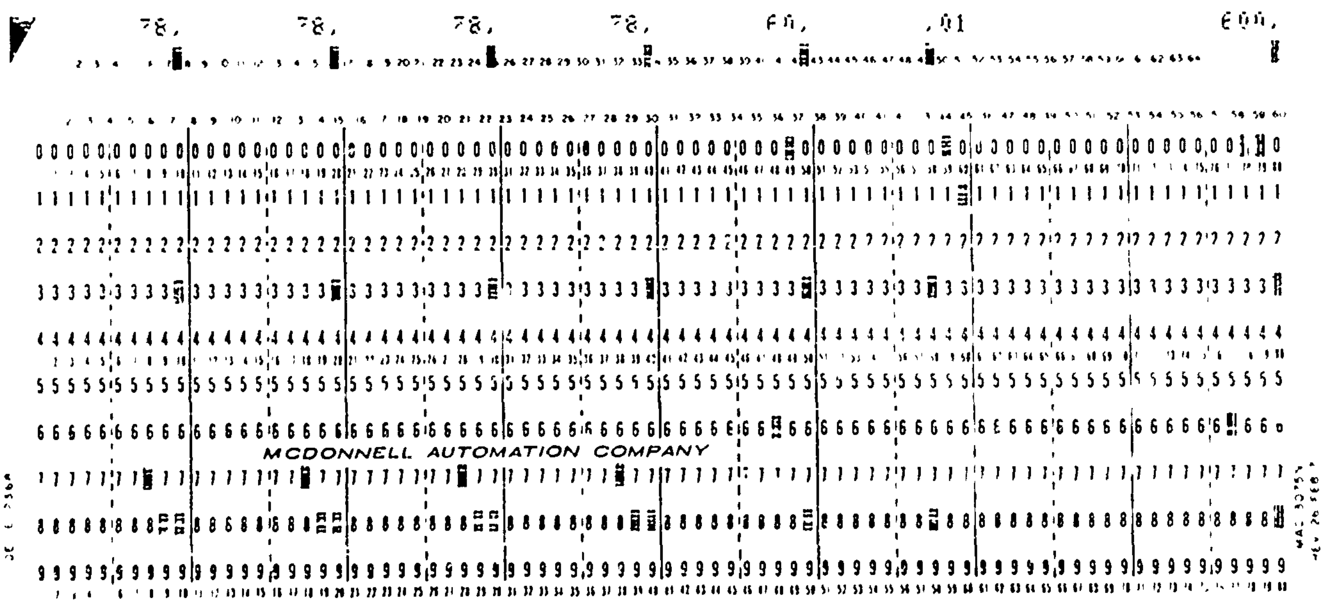
COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	TEMPERATURE OF THE SURROUNDING STRUCTURE	°F
11-20	E10.0	TEMPERATURE OF THE SURROUNDING ATMOSPHERE	°F
21-30	E10.0	INITIAL TEMPERATURE OF THE FLUID	°F
31-40	E10.0	INITIAL TEMPERATURE OF THE WALLS	°F
41-50	E10.0	INITIAL TEMPERATURE OF THE COOLING LIQUID	°F
51-60	E10.0	LAMINAR FLOW COEFF. *	PSI/CIS
61-70	E10.0	NOT USED	
71-80	E10.0	COOLING LIQUID PRESSURE PROP, INLET TO OUTLET	PSI

* Note: This value is determined using the relationship

$$\Delta P = LAM*Q$$

where ΔP is the entry/exit pressure loss for MIL-H-5606B at 100°F.

EXAMPLE CARD



6.70 ACCUMULATORS

There are many varieties of accumulators. The three types that are in common usage are free piston accumulator, bladder accumulator and tandem piston accumulator (F-15 JFS accumulator). The following type is currently included in the program:

Type #71 Free Piston Accumulator (TACUM71)

The accumulator subroutine is setup based on using dry nitrogen gas.

6.71 TYPE #71 FREE PISTON ACCUMULATOR

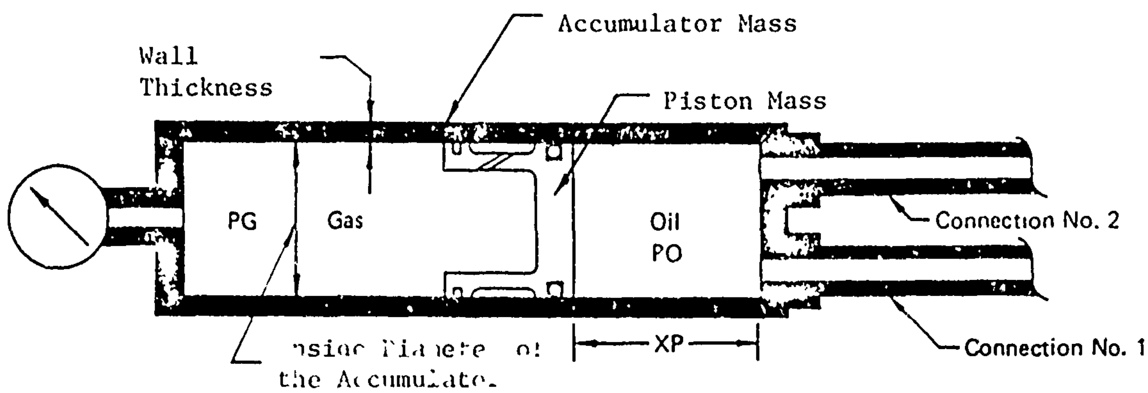


FIGURE 6.71-1
TYPE NO. 71 FREE PISTON ACCUMULATOR

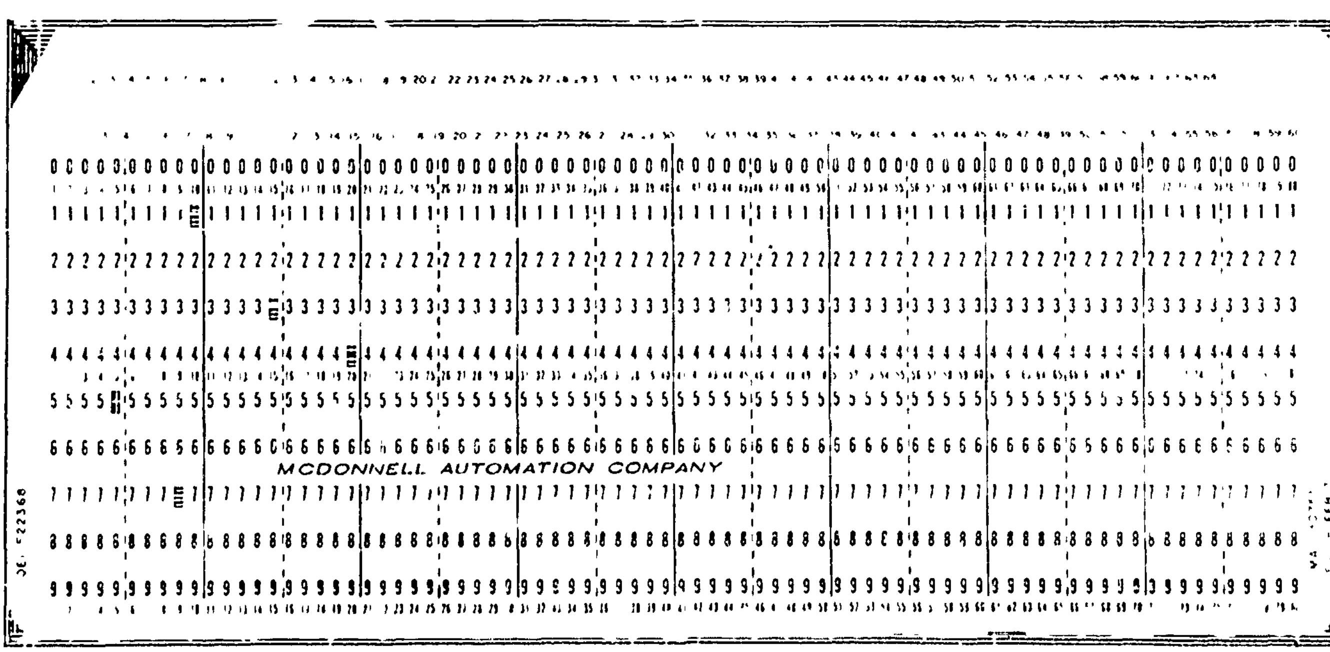
The input data for the Type #71 accumulator are basically the minimum and maximum gas and oil volumes and the precharge pressure. The gas and oil piston areas are assumed to be equal. The accumulator oil fluid temperature, gas temperature, piston and wall temperatures are computed.

TACUM71

CARD NUMBER 1

COLUMN	FORMAT	DATA
1-5	I5	Component Number
6-10	I5	Type Number = 71
11-15	I5	Number of Real Data Cards =3
16-20	I5	Line Number (with sign) attached to Connection 1
21-25	I5	Line Number (with sign) attached to Connection 2
26-30	I5	
31-35	I5	
36-40	I5	
41-45	I5	
46-50	I5	
51-55	I5	
56-60	I5	
61-65	I5	
66-70	I5	
71-75	I5	
76-80	I5	

EXAMPLE CARD

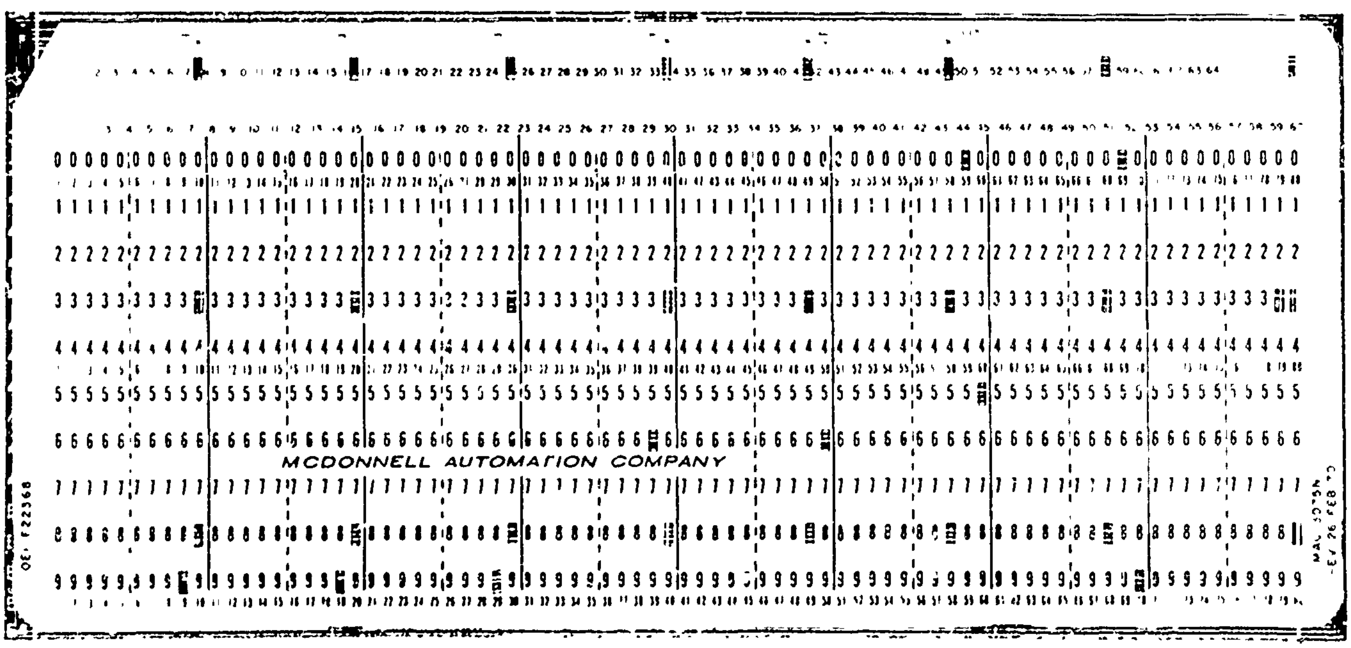


TACUM71

CARD NUMBER 2

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	ACCUMULATOR MATERIAL TYPE	--
11-20	E10.0	GAS TYPE (NOT USED)	--
21-30	E10.0	PISTON MATERIAL TYPE	--
31-40	E10.0	ACCUMULATOR MASS	LB_m
41-50	E10.0	PISTON MASS	LB_m
51-60	E10.0	WALL THICKNESS	IN.
61-70	E10.0	HEAT TRANSFER COEF. OIL TO WALL AND PISTON	WATTS/IN^2-°F
71-80	E10.0	INSIDE DIAMETER OF THE ACCUMULATOR	IN.

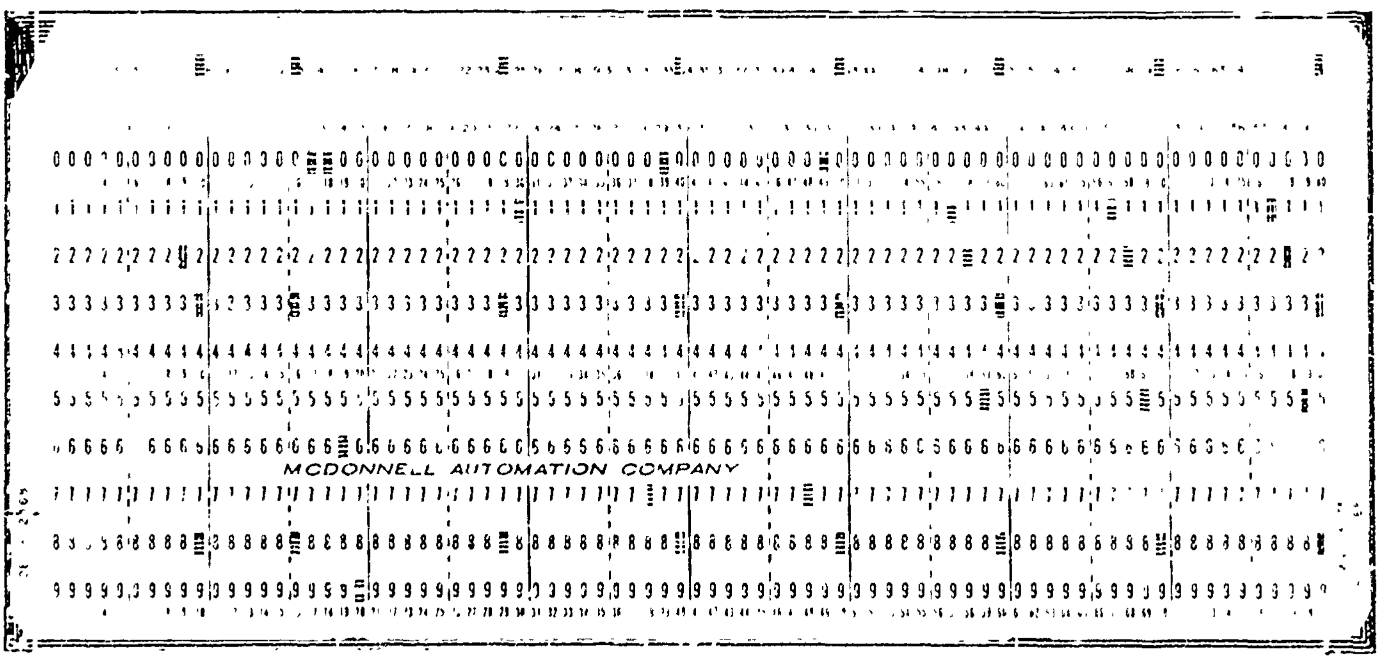
EXAMPLE CARD



CARD NUMBER 3

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	SURFACE AREA ACCUMULATOR WALLS TO ATMOSPHERE	$IN.^2$
11-20	E10.0	HEAT TRANSFER COEF. GAS TO WALLS	$WATTS/IN.^2$-°F
21-30	E10.0	HEAT TRANSFER COEF. ATMOSPHERE TO WALLS	$WATTS/IN.^2$-°F
31-40	E10.0	INTERFACE CONDUCTANCE PISTON TO WALLS	WATTS/IN.-°F
41-50	E10.0	SURROUNDING STRUCTURE TEMPERATURE	°F
51-60	E10.0	SURROUNDING ATMOSPHERE TEMPERATURE	°F
61-70	E10.0	INITIAL TEMPERATURE OF THE WALLS	°F
71-80	E10.0	INITIAL TEMPERATURE OF THE FLUID	°F

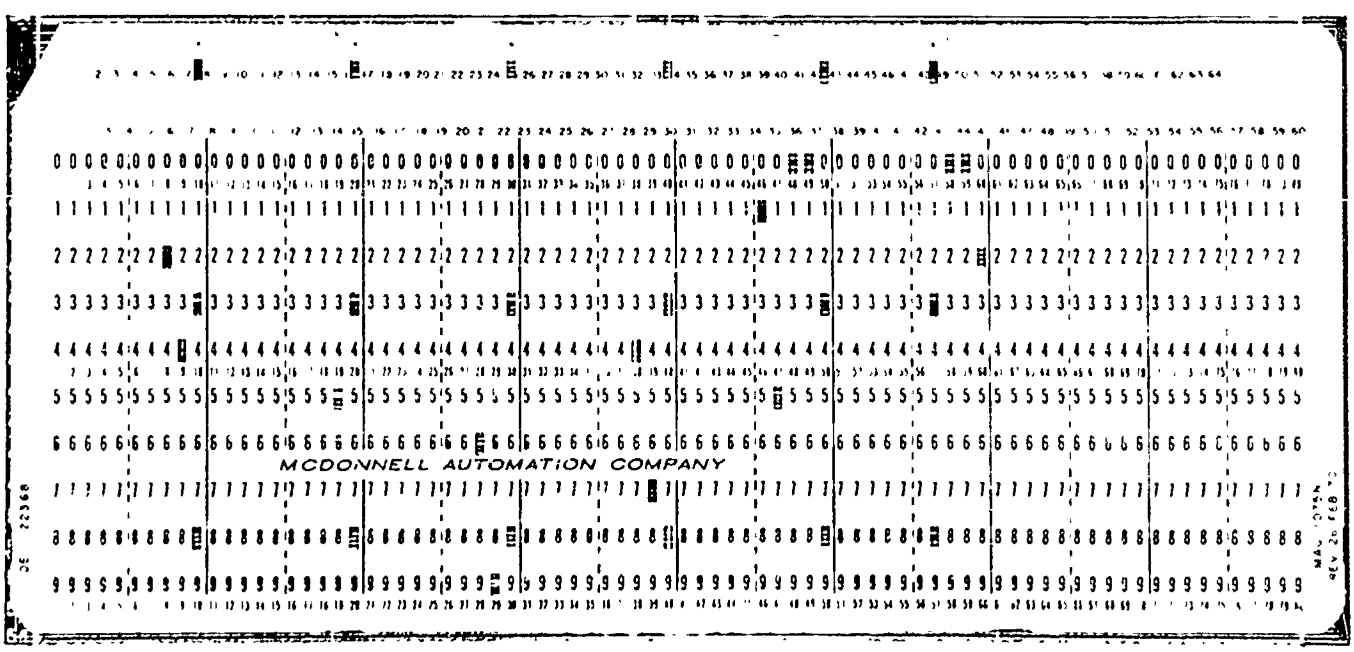
EXAMPLE CARD



CARD NUMBER 4

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	INITIAL TEMPERATURE OF THE GAS	°F
11-20	E10.0	PISTON TO OIL AREA	$IN.^2$
21-30	E10.0	MINIMUM OIL VOLUME	$IN.^3$
31-40	E10.0	MAXIMUM OIL VOLUME	$IN.^3$
41-50	E10.0	MINIMUM GAS VOLUME	$IN.^3$
51-60	E10.0	PRECHARGE GAS PRESSURE @ 100°F	PSI
61-70	E10.0	ENTRANCE AND EXIT LOSSES @ 100°F FOR MIL-H-5606B	PSI/CIS
71-80	E10.0		

EXAMPLE CARD



6.80 FILTER

There are numerous type filter elements and filter bodies to contain them. Often the bodies have multiple functions, external and internal connections. Hence only one filter has been modeled, general enough to include many simple filters. The following is included in the program:

TYPE #81 F-4 TYPE IN-LINE FILTER (TFILT81)

6.81 TYPE #81 F-4 TYPE IN-LINE FILTER

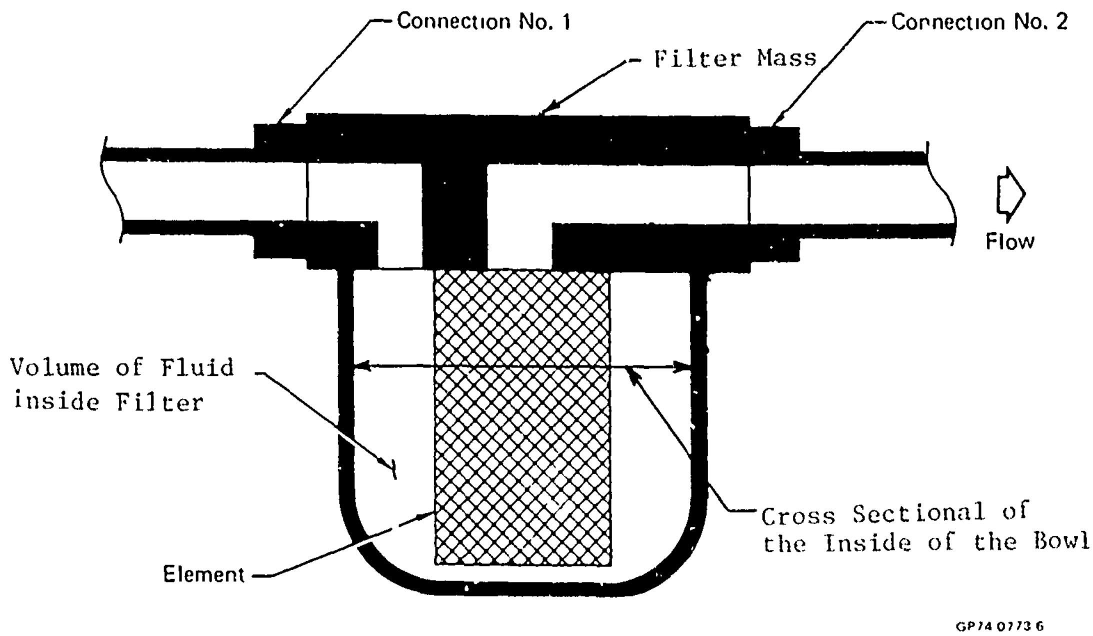


FIGURE 6.81-1
TYPE NO. 81 F-4 TYPE IN-LINE FILTER

The Type #81 F-4 in-line filters are simple non-bypass units using standard cleanable elements.

This particular type will be used in simulation work because it is simple and has no ancillary components.

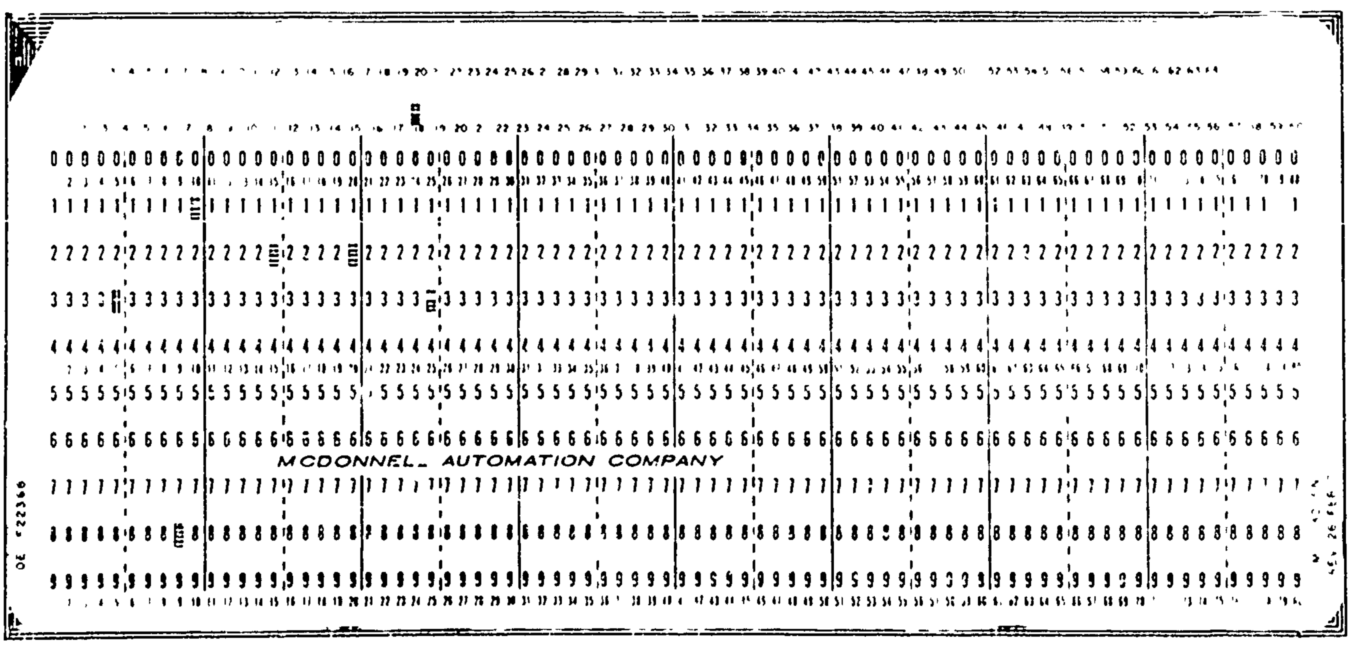
The program computes the filter fluid and wall temperatures.

TFILT81

CARD NUMBER 1

COLUMN	FORMAT	DATA
1-5	I5	Component Number
6-10	I5	Type Number = 81
11-15	I5	Number of Real Data Cards = 2
16-20	I5	Line Number (with sign) attached to Connection 1
21-25	I5	Line Number (with sign) attached to Connection 2
26-30	I5	
31-35	I5	
36-40	I5	
41-45	I5	
46-50	I5	
51-55	I5	
56-60	I5	
61-65	I5	
66-70	I5	
71-75	I5	
76-80	I5	

EXAMPLE CARD

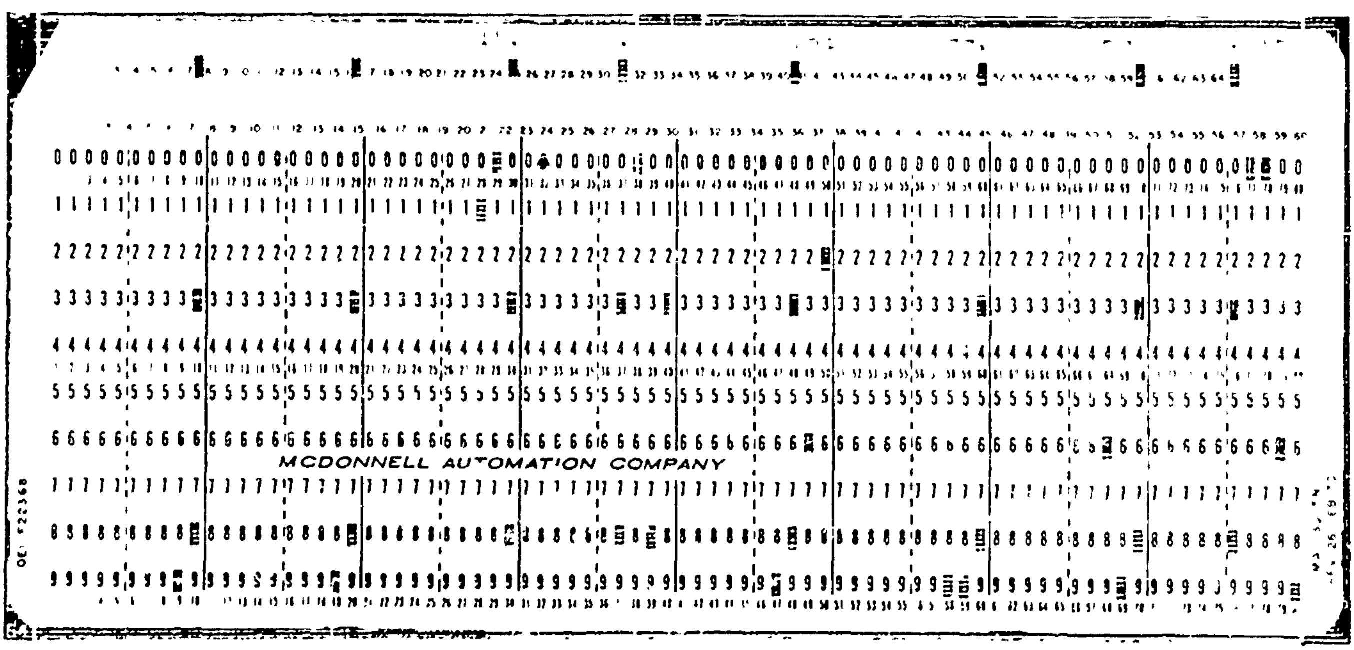


TFILT81

CARD NUMBER 2

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	FILTER CASE MATERIAL TYPE	--
11-20	E10.0	FILTER CASE MASS	LB_m
21-30	E10.0	VOLUME OF FLUID INSIDE FILTER	IN.^{3}
31-40	E10.0	CROSS SECTIONAL AREA OF WALLS(INLET & OUTLET)	IN.^{2}
41-50	E10.0	CROSS SECTIONAL AREA OF THE INSIDE OF THE BOWL	IN.^{2}
51-60	E10.0	SURFACE AREA FILTER CASE TO ATMOSPHERE	IN.^{2}
61-70	E10.0	SURFACE AREA FLUID TO FILTER CASE	IN.^{2}
71-80	E10.0	HEAT TRANSFER COEFF ATMOSPHERE OF FILTER CASE	WATTS/IN^2-°F

EXAMPLE CARD

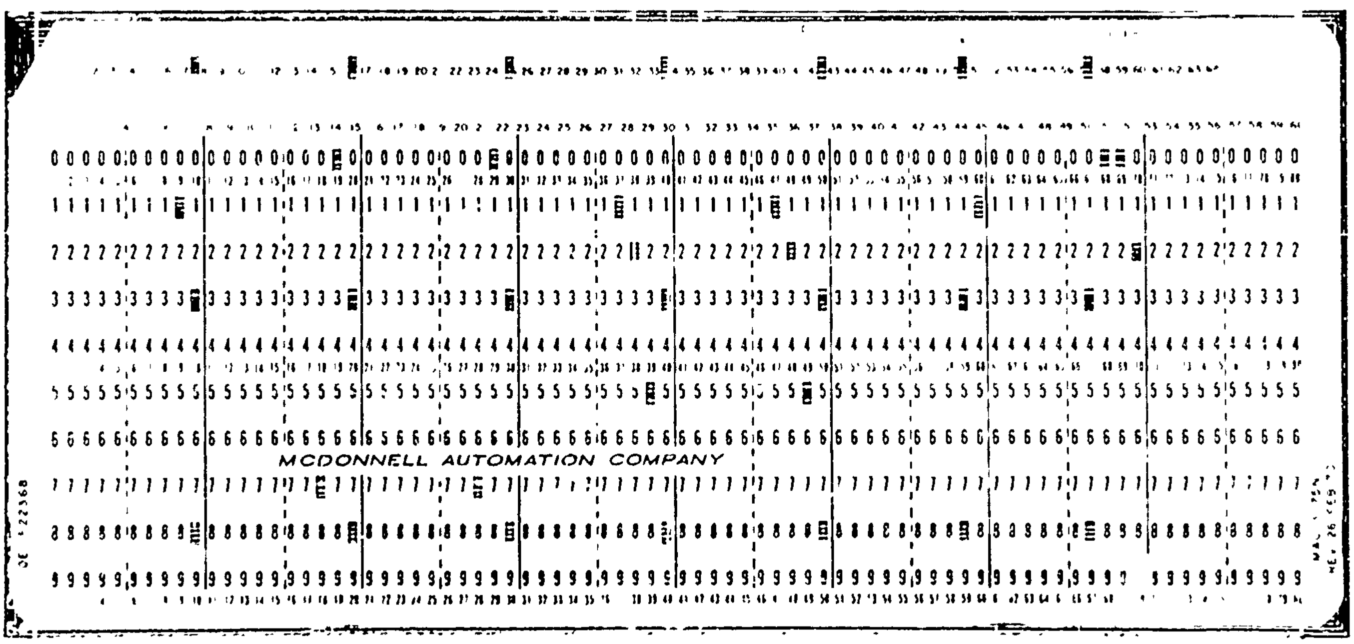


CARD NUMBER 3

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	PERCENTAGE HEAT ADDED TO FLUID (DUE TO ΔP)	--
11-20	E10.0	SURROUNDING STRUCTURE TEMPERATURE	°F
21-30	E10.0	SURROUNDING ATMOSPHERE TEMPERATURE	°F
31-40	E10.0	INITIAL TEMPERATURE OF THE FLUID	°F
41-50	E10.0	INITIAL TEMPERATURE OF THE WALLS	°F
51-60	E10.0	LINEAR ELEMENT FLOW CONSTANT *	PSI/CIS
61-70	E10.0	NON-LINEAR ELEMENT FLOW CONSTANT *	PSI/CIS^2
71-80	E10.0		

* Input for MIL-H-5606B at 100°

EXAMPLE CARD



6.100 ACTUATORS

The actuator models are setup for a specific actuator or for a general type. The general type can be used to simulate actuators by using the appropriate input data, if the general configuration is close enough to be acceptable. The following types are currently available.

Type #101 Valve Controlled Actuator (TACT101)

Type #102 Utility Actuator (TACT102)

Note: Zero stroke (noted in the input data) is defined as the piston position when actuator is fully retracted.

6.101 TYPE #101 VALVE CONTROLLED ACTUATOR

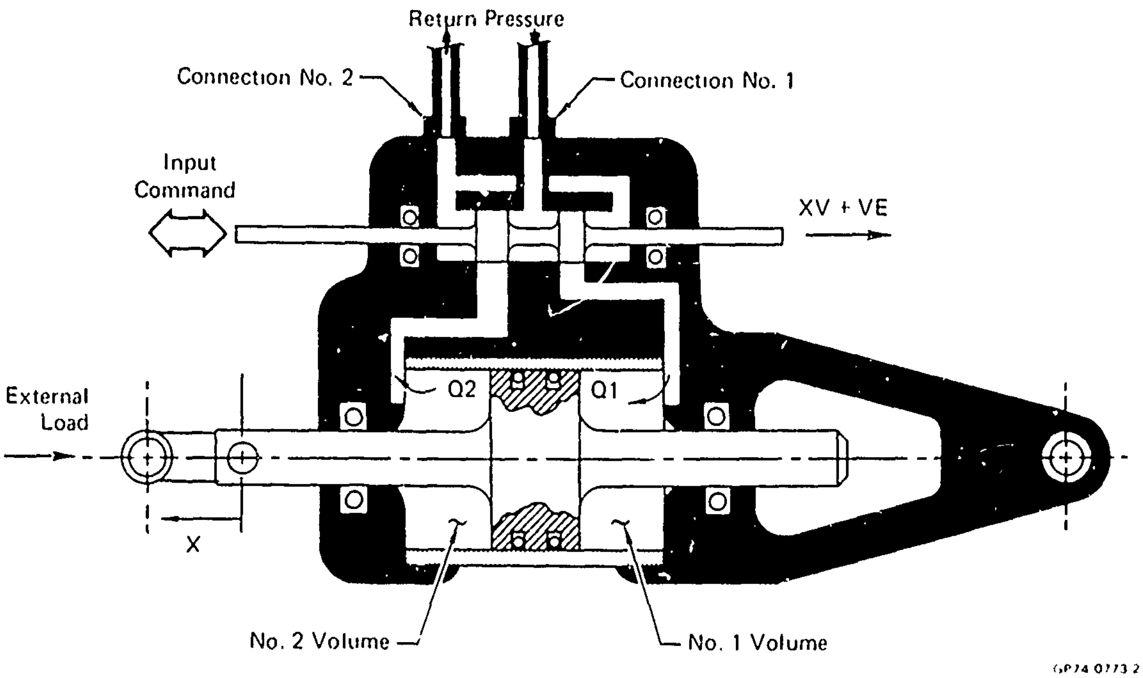


FIGURE 6.101-1
TYPE NO. 101 VALVE CONTROLLED ACTUATOR

The valve controlled actuator is an actuator with an integral valve that is typical of servoactuators. One line is connected to pressure port and one line is connected to return port. Actuator designs that can be used are as follows:

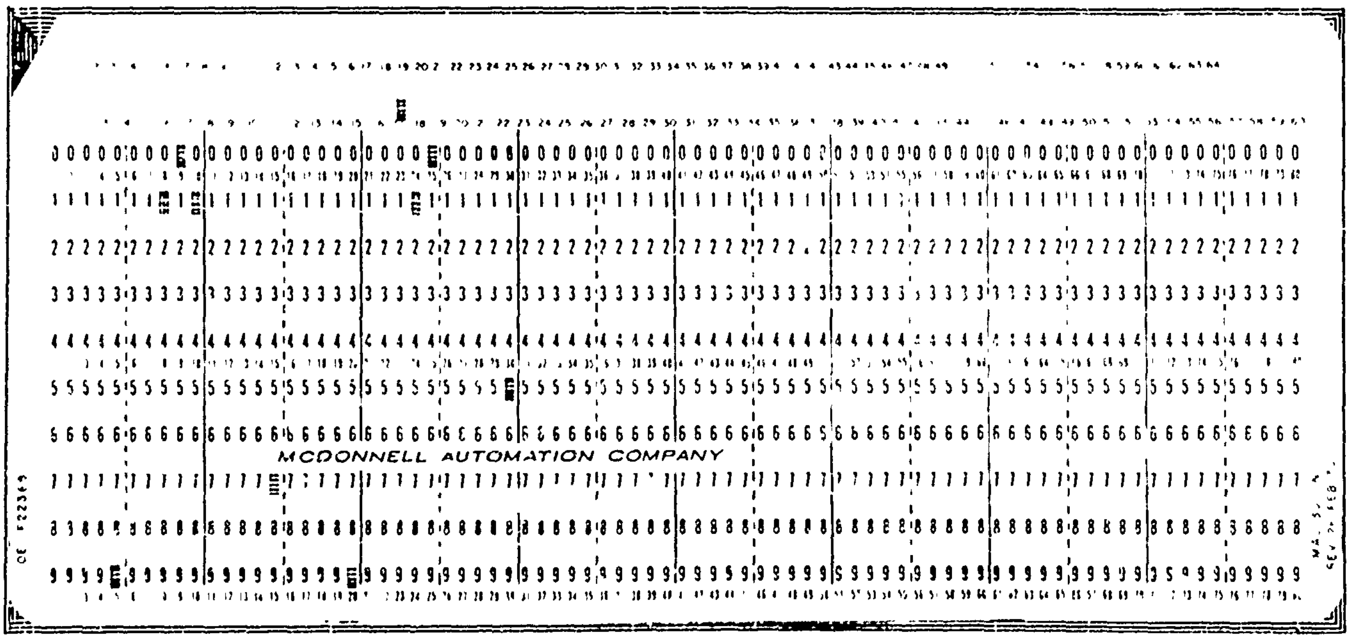
- Balanced actuator
- Unbalanced actuator
- Partially balanced actuator
- Parallel balanced or unbalanced actuator (provided all piston rods react a common load).

Three wall temperatures, four fluid, and one piston temperatures are calculated.

CARD NUMBER 1

COLUMN	FORMAT	DATA
1-5	I5	Component Number
6-10	I5	Type Number = 101
11-15	I5	Number of Real Data Cards = / or more
16-20	I5	Line Number (with sign) attached to Connection 1
21-25	I5	Line Number (with sign) attached to Connection 2
26-30	I5	
31-35	I5	
36-40	I5	
41-45	I5	
46-50	I5	
51-55	I5	
56-60	I5	
61-65	I5	
66-70	I5	
71-75	I5	
76-80	I5	

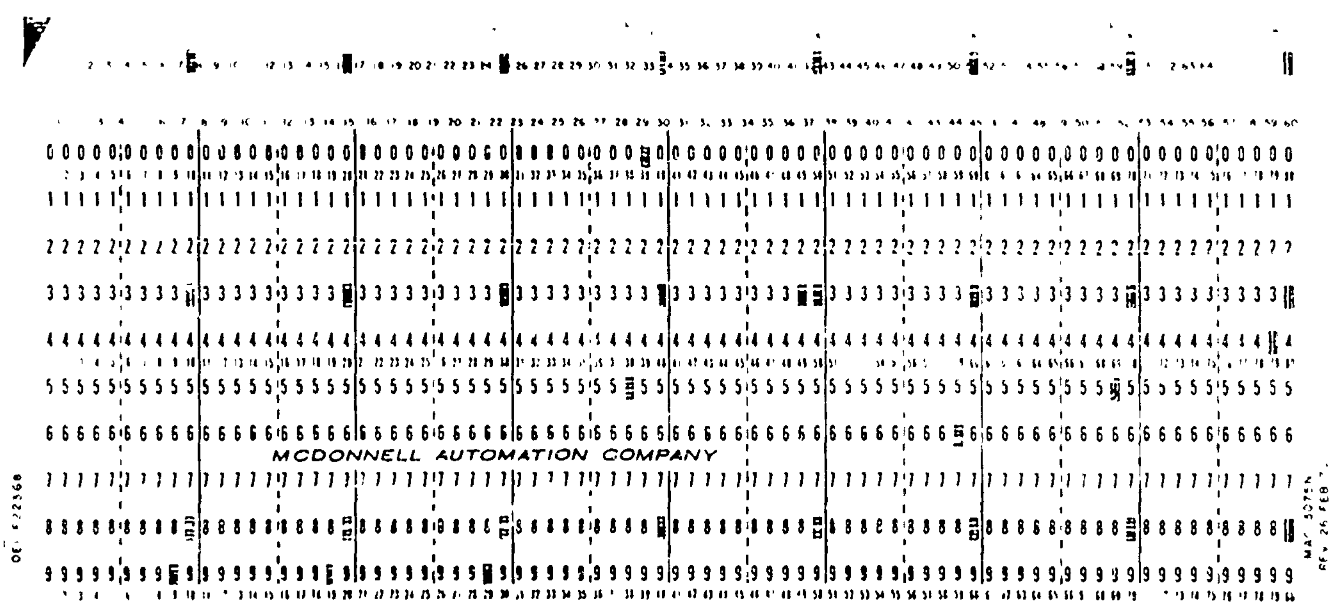
EXAMPLE CARD



CARD NUMBER 2

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	ACTUATOR MATERIAL TYPE	--
11-20	E10.0	PISTON MATERIAL TYPE	--
21-30	E10.0	VALVE MATERIAL TYPE	--
31-40	E10.0	ACTUATOR MASS	LB_m
41-50	E10.0	VALVE MASS	LB_m
51-60	E10.0	SURFACE AREA PISTON TO VOLUME ONE	$IN.^2$
61-70	E10.0	SURFACE AREA PISTON TO VOLUME TWO	$IN.^2$
71-80	E10.0	INTERNAL VOLUME OF THE VALVE	$IN.^3$

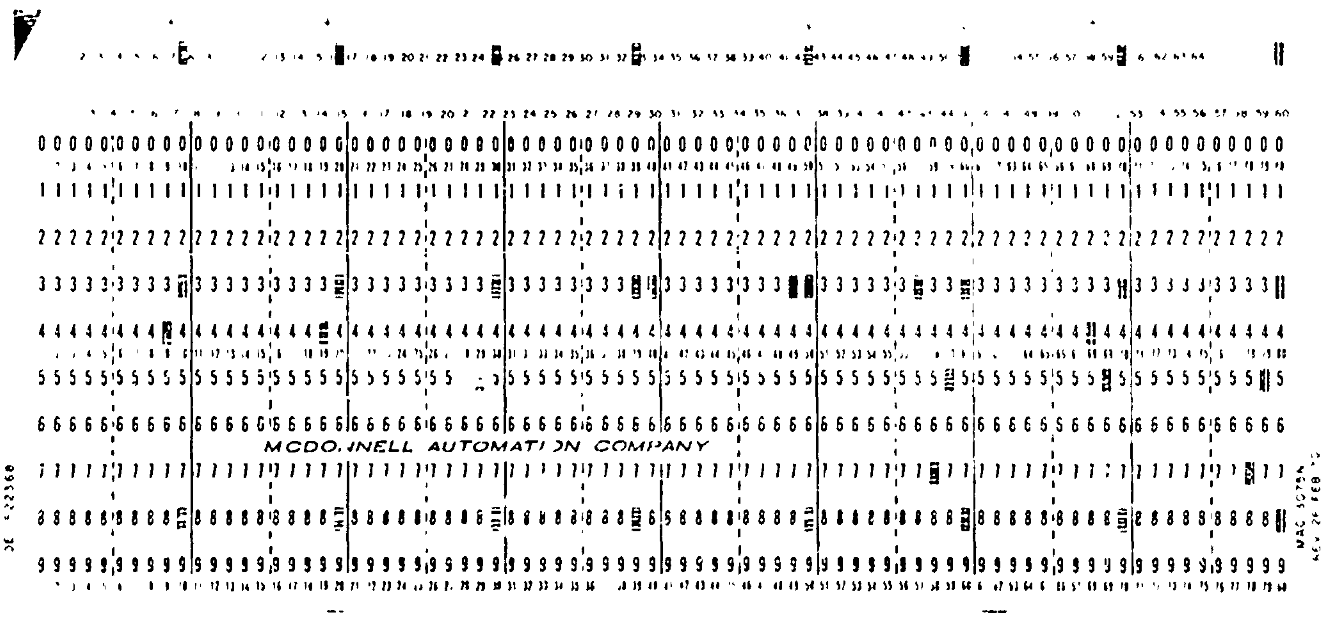
EXAMPLE CARD



CARD NUMBER 3

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	DISTANCE FROM INLET TO VOLUME ONE	IN.
11-20	E10.0	DISTANCE FROM EXIT TO VOLUME TWO	IN.
21-30	E10.0	DISTANCE FROM INLET TO VOLUME TWO	IN.
31-40	E10.0	PISTON WALL THICKNESS	IN.
41-50	E10.0	PISTON HEIGHT	IN.
51-60	E10.0	EXTERNAL SURFACE AREA OF THE ACTUATOR	$IN.^2$
61-70	E10.0	CONTACT AREA, VALVE TO ACTUATOR	$IN.^2$
71-80	E10.0	EXTERNAL SURFACE AREA OF THE VALVE	$IN.^2$

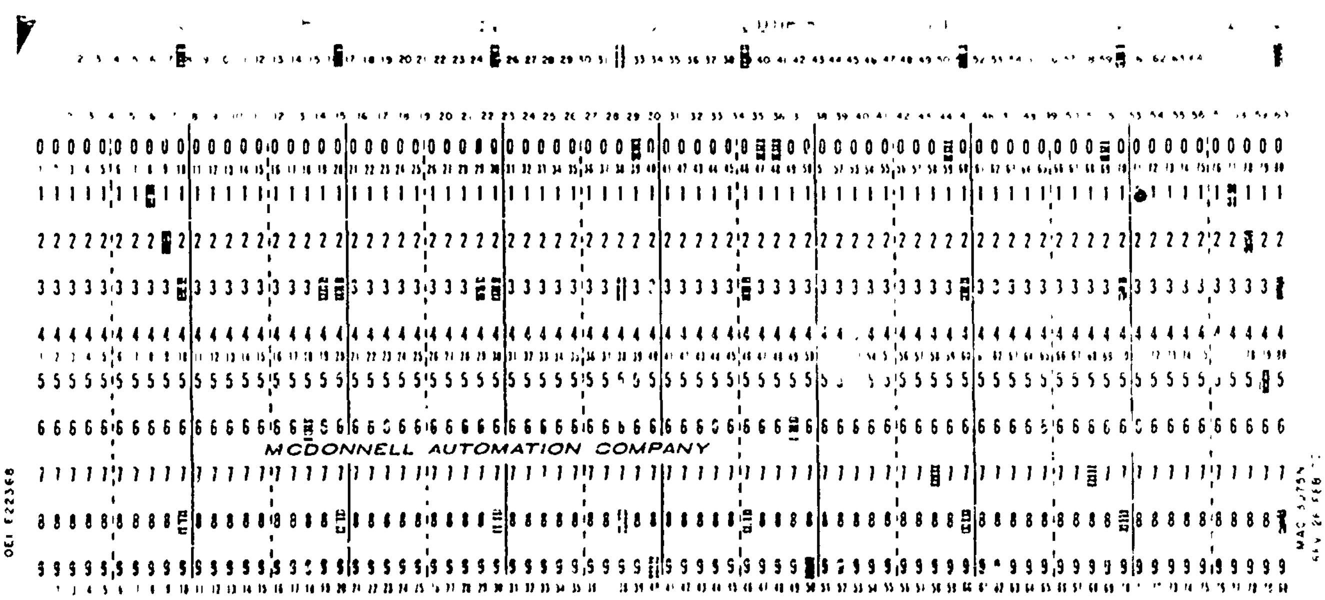
EXAMPLE CARD



CARD NUMBER 4

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	INTERNAL SURFACE AREA OF THE VALVE	$IN.^2$
11-20	E10.0	INTERNAL SURFACE AREA OF ACTUATOR WALLS TO FLUID	$IN.^2$
21-30	E10.0	INTERFACE CONDUCTANCE, VALVE TO ACTUATOR	$WATTS/IN.^2$-°F
31-40	E10.0	HEAT TRANSFER COEFFICIENT, FLUID ONE TO PISTON	$WATTS/IN^2$-°F
41-50	E10.0	HEAT TRANSFER COEFFICIENT, VALVE TO ATMOSPHERE	$WATTS/IN^2$-°F
51-60	E10.0	SURROUNDING STRUCTURE TEMPERATURE	°F
61-70	E10.0	SURROUNDING ATMOSPHERIC TEMPERATURE	°F
71-80	E10.0	INITIAL TEMPERATURE OF THE FLUID	°F

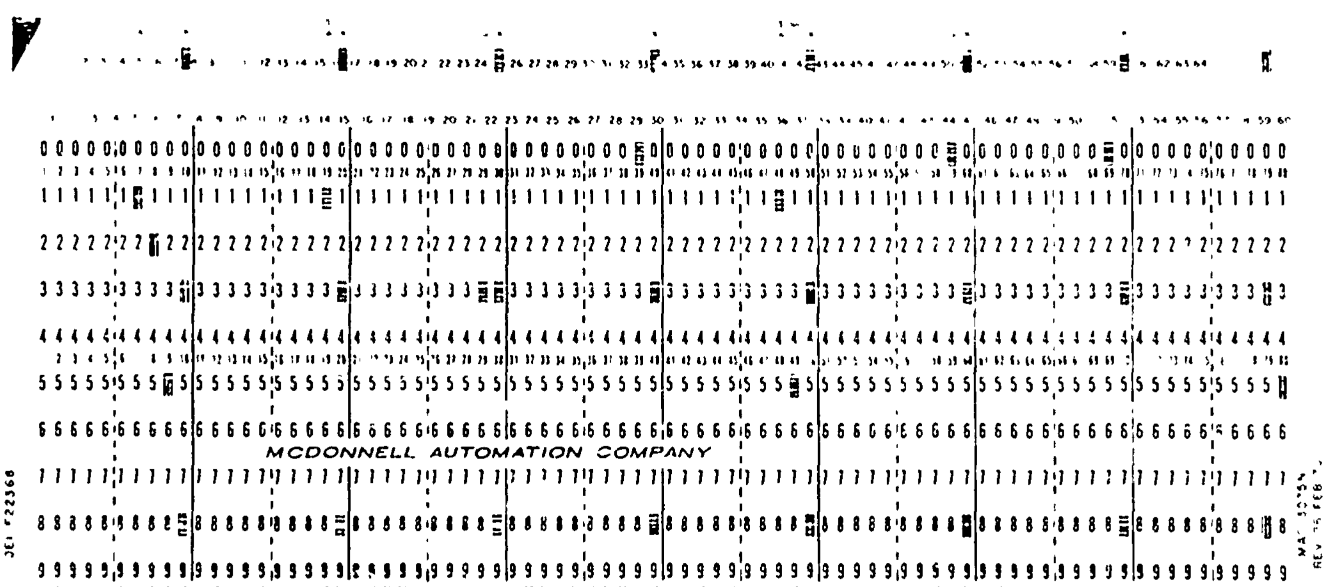
EXAMPLE CARD



CARD NUMBER 5

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	INITIAL TEMPERATURE OF THE WALLS	°F
11-20	E10.0	PERCENTAGE HEAT ADDED TO FLUID DUE TO ΔP	--
21-30	E10.0	INITIAL ACTUATOR POSITION	IN
31-40	E10.0	STROKE WITH ACTUATOR FULLY RETRACTED	IN
41-50	E10.0	STROKE WITH ACTUATOR FULLY EXTENDED	IN
51-60	E10.0	COMPRESSIVE LOAD WITH ACTUATOR FULLY RETRACTED	LBS
61-70	E10.0	COMPRESSIVE LOAD WITH ACTUATOR FULLY EXTENDED	LBS
71-80	E10.0	STATIC SEAL FRICTION	LB_f

EXAMPLE CARD

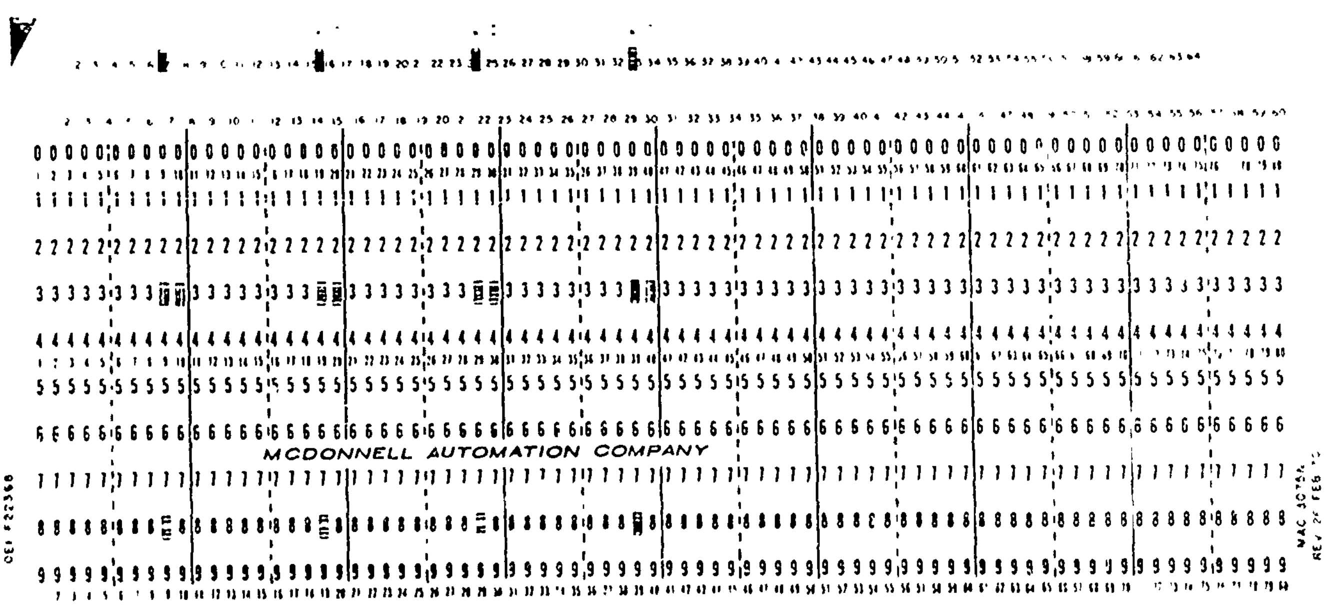


CARD NUMBER 6

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	SLOT WIDTH VOL #1 TO CON #1 (WHEN XV* IS POSITIVE)	IN
11-20	E10.0	SLOT WIDTH VOL #1 TO CON #2 (WHEN XV IS NEGATIVE)	IN
21-30	E10.0	SLOT WIDTH VOL #2 TO CON #1 (WHEN XV IS NEGATIVE)	IN
31-40	E10.0	SLOT WIDTH VOL #2 TO CON #2 (WHEN XV IS POSITIVE)	IN
41-50	E10.0		
51-60	E10.0		
61-70	E10.0		
71-80	E10.0		

* Note: XV is vale position.

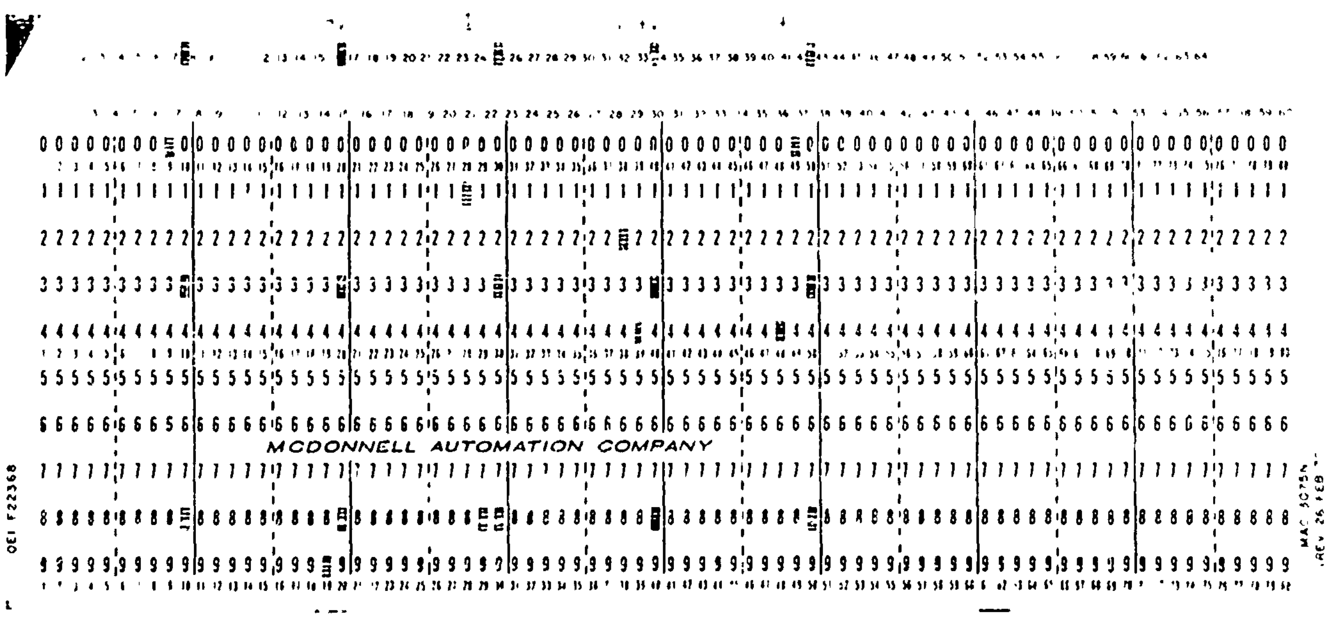
EXAMPLE CARD



CARD NUMBER 7

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	FIRST TIME VALUE AT TIME T = 0.0	SEC.
11-20	E10.0	(ENTER AS MANY TIME VALUES	
21-30	E10.0	AS REQUIRED USING AS MANY COLUMNS AND CARDS AS NECESSARY	
31-40	E10.0	FINAL TIME SHOULD BE FINAL	
41-50	E10.0	CALCULATION TIME)	
51-60	E10.0		
61-70	E10.0		
71-80	E10.0		

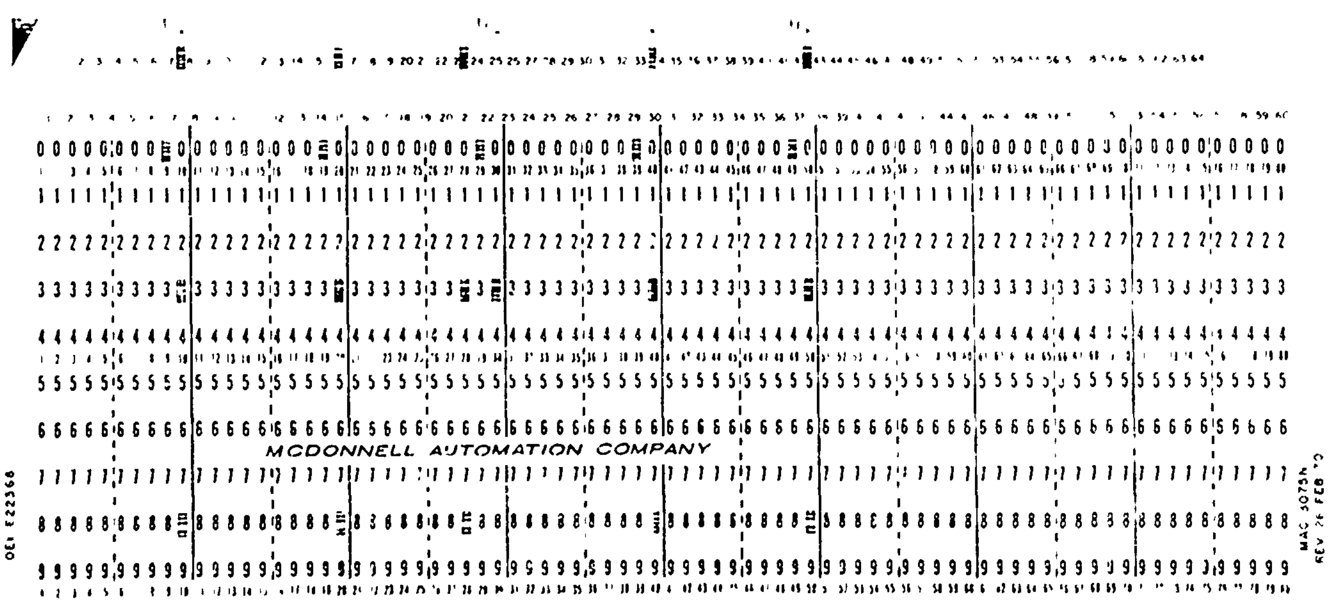
EXAMPLE CARD



CARD NUMBER 8

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	INITIAL VALVE POSITION @ T-0	IN.
11-20	E10.0	(ENTER AS MANY VALVE	
21-30	E10.0	POSITIONS AS TIME	
31-40	E10.0	VALVES)	
41-50	E10.0		
51-60	E10.0		
61-70	E10.0		
71-80	E10.0		

EXAMPLE CARD



6.102 TYPE #102 UTILITY ACTUATOR

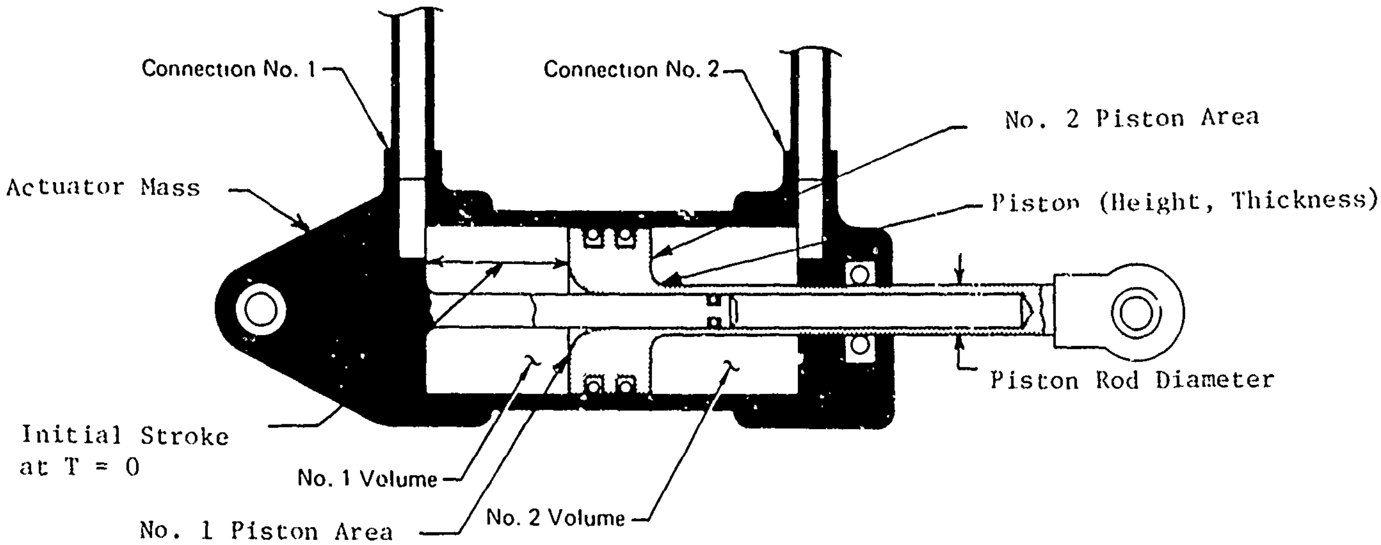


FIGURE 6.102-1
TYPE NO. 102 UTILITY ACTUATOR

This is a simple utility type actuator with a line connected to the extend port and a line connected to the retract port. Actuator designs that can be used are as follows:

- o Balanced actuator
- o Unbalanced actuator
- o Partially balanced actuator
- o Parallel balanced or unbalanced actuator (provided piston rods react a common load).

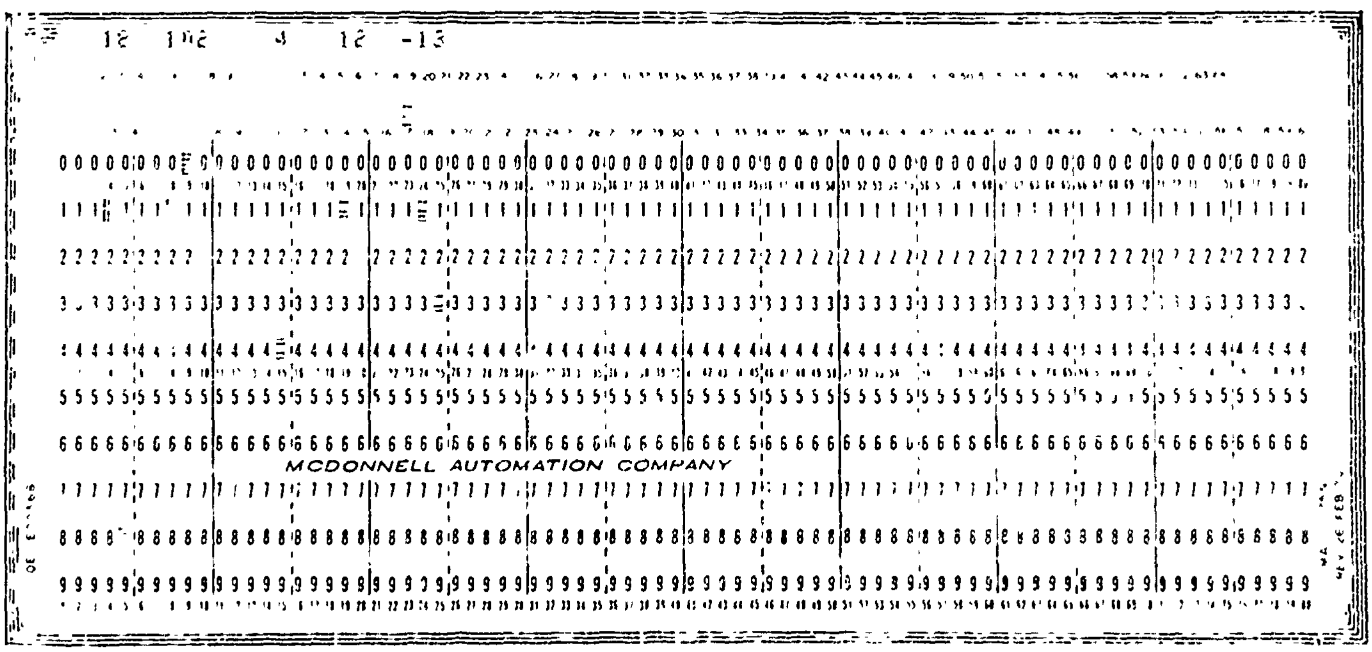
The actuator fluid, piston and wall temperatures are computed.

TACT102

CARD NUMBER 1

COLUMN	FORMAT	DATA
1-5	I5	Component Number
6-10	I5	Type Number = 102
11-15	I5	Number of Real Data Cards = 4
16-20	I5	Line Number (with sign) attached to Connection 1
21-25	I5	Line Number (with sign) attached to Connection 2
26-30	I5	
31-35	I5	
36-40	I5	
41-45	I5	
46-50	I5	
51-55	I5	
56-60	I5	
61-65	I5	
66-70	I5	
71-75	I5	
76-80	I5	

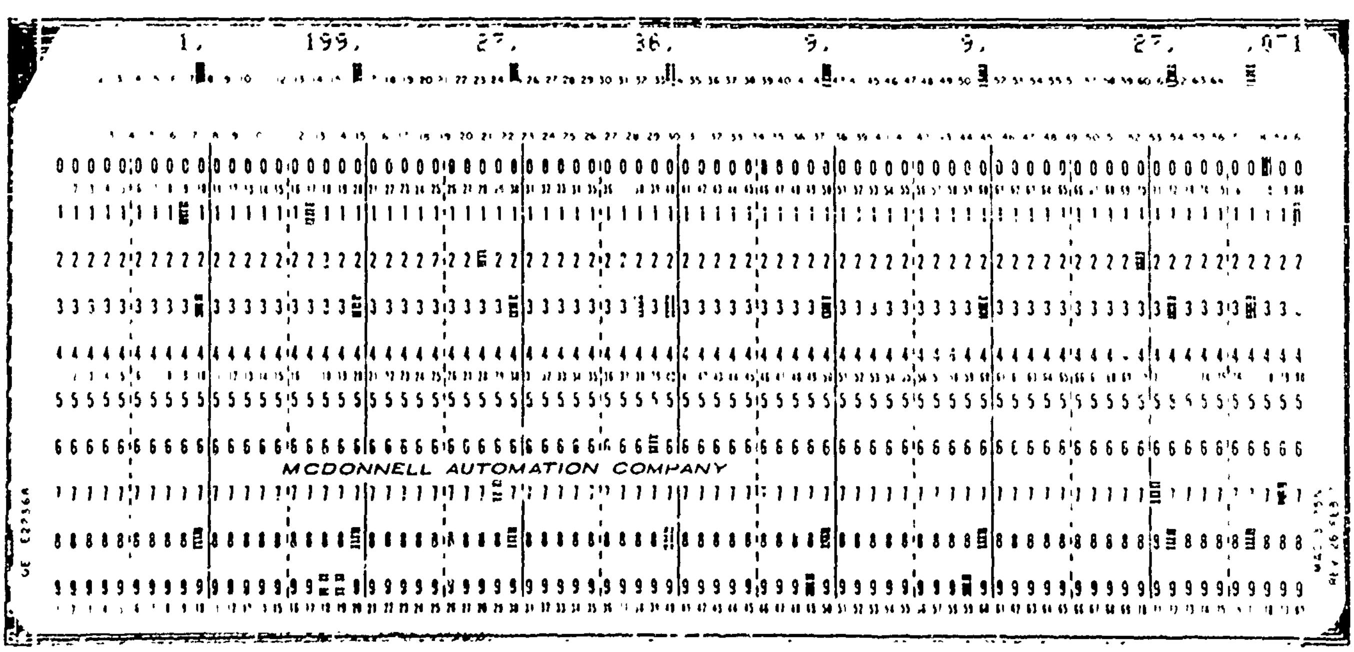
EXAMPLE CARD



CARD NUMBER 2

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	#1 VOLUME AT ZERO STROKE	$IN.^3$
11-20	E10.0	#2 VOLUME AT ZERO STROKE	$IN.^3$
21-30	E10.0	#1 PISTON AREA (EXTENDED)	$IN.^2$
31-40	E10.0	#2 PISTON AREA (RETRACTED)	$IN.^2$
41-50	E10.0	ACTUATOR MATERIAL TYPE	
51-60	E10.0	PISTON MATERIAL TYPE	
61-70	E10.0	ACTUATOR MASS	LB_m
71-80	E10.0	ACTUATOR WALL THICKNESS	IN.

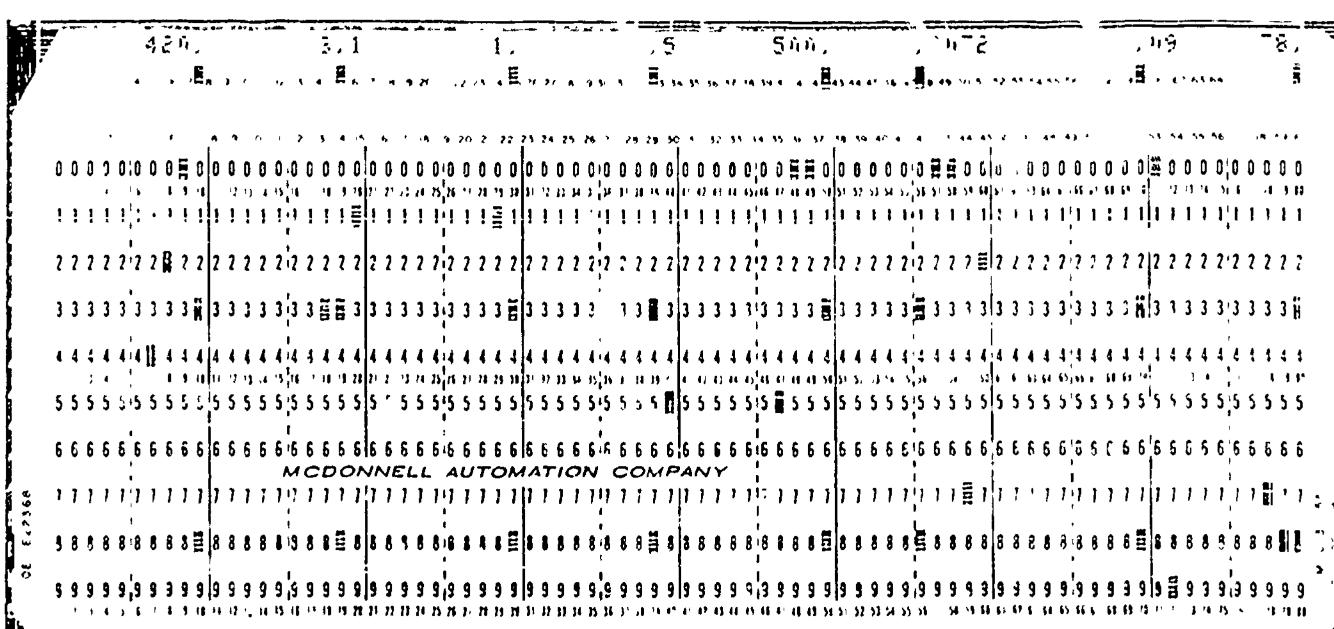
EXAMPLE CARD



CARD NUMBER 3

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	SURFACE AREA FLUID TO ACTUATOR (NOT INCLUDING PISTON AREA)	$IN.^2$
11-20	E10.0	PISTON HEIGHT	IN.
21-30	E10.0	PISTON THICKNESS	IN.
31-40	E10.0	PISTON ROD DIAMETER	IN.
41-50	E10.0	SURFACE AREA ACTUATOR CASE TO ATMOSPHERE	$IN.^2$
51-60	E10.0	HEAT TRANSFER COEFF ACTUATOR TO ATMOSPHERE	$WATTS/IN.^2-°F$
61-70	E10.0	HEAT TRANSFER COEFF FLUID TO PISTON	$WATTS/IN.^2-°F$
71-80	E10.0	SURROUNDING STRUCTURE TEMPERATURE	°F

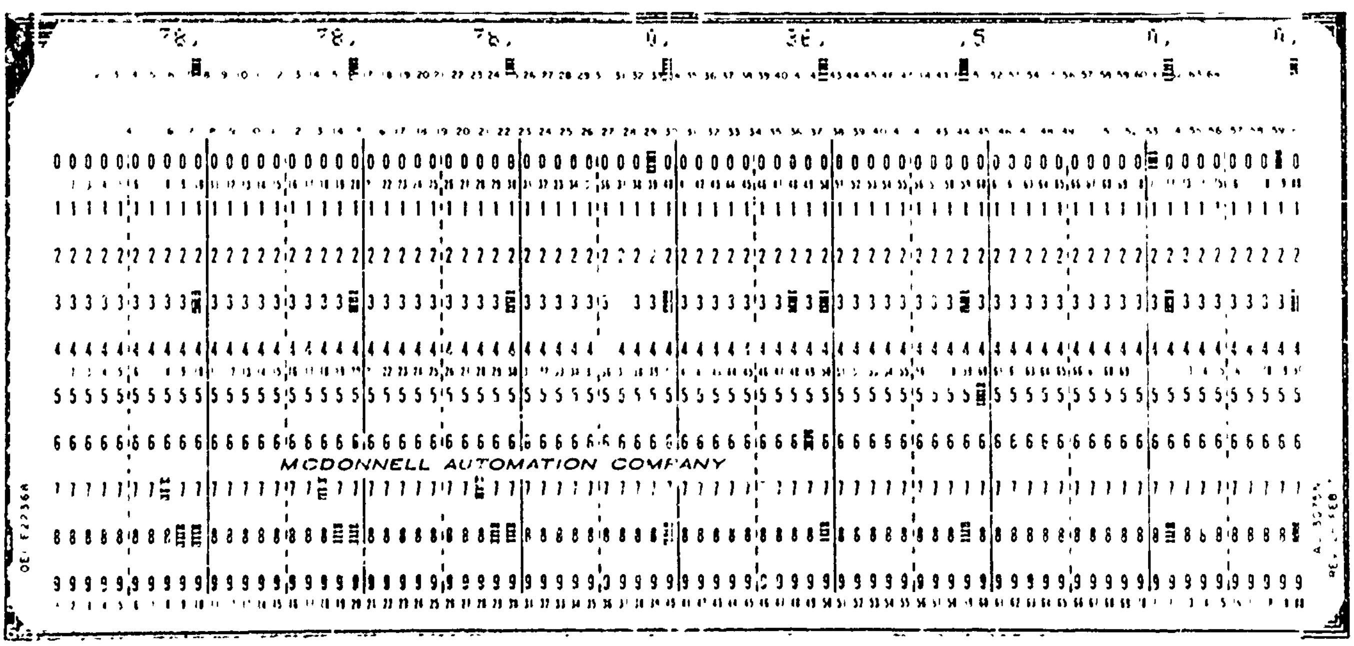
EXAMPLE CARD



CARD NUMBER 4

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	SURROUNDING ATMOSPHERE TEMPERATURE	°F
11-20	E10.0	INITIAL TEMPERATURE OF THE FLUID	°F
21-30	E10.0	INITIAL TEMPERATURE OF THE CASE	°F
31-40	E10.0	STROKE AT MINIMUM POSITION (-VE OR ZERO)	IN.
41-50	E10.0	STROKE AT MAXIMUM POSITION (+VE OR ZERO)	IN.
51-60	E10.0	SEAL FRICTION	LB_f
61-70	E10.0	LOAD AT MIN. STROKE (RETRACTED)	LB.
71-80	E10.0	LOAD AT MAX. STROKE (EXTENDED)	LB.

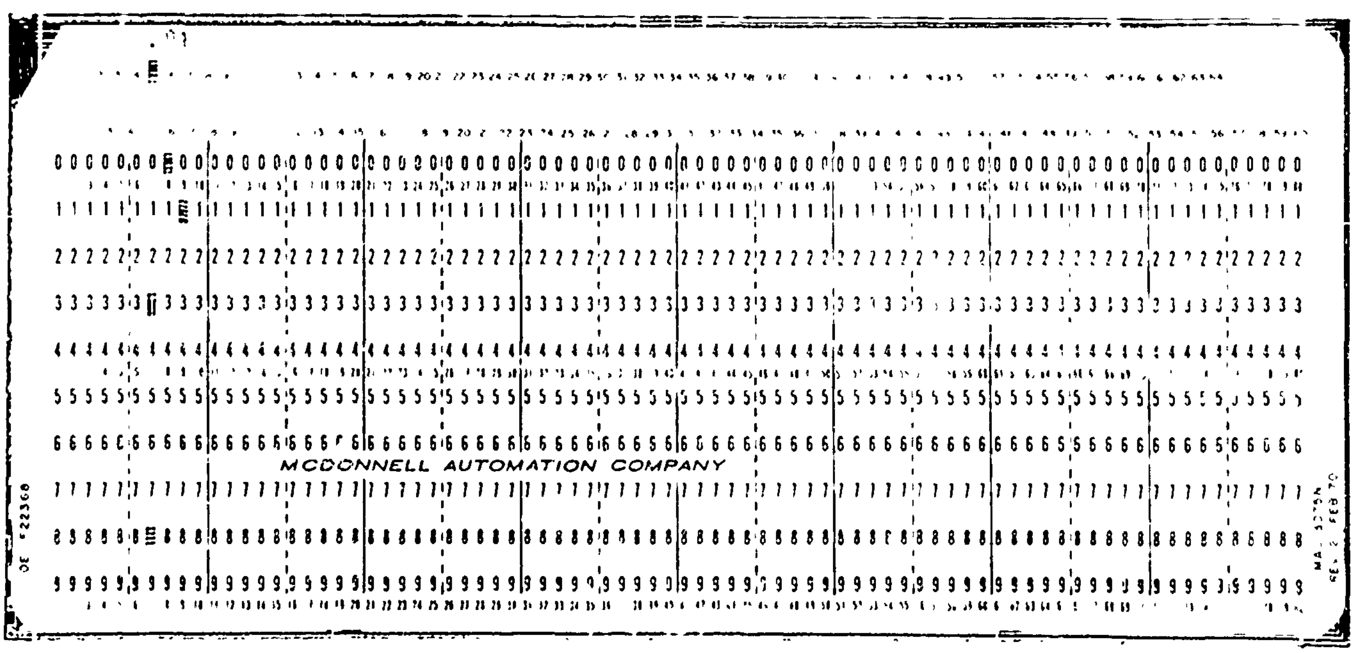
EXAMPLE CARD



CARD NUMBER 5

COLUMN	FORMAT	DATA	DIMENSIONS
1-10	E10.0	INITIAL STROKE AT TIME T = 0.0	IN.
11-20	E10.0		
21-30	E10.0		
31-40	E10.0		
41-50	E10.0		
51-60	E10.0		
61-70	E10.0		
71-80	E10.0		

EXAMPLE CARD



7.0 SYSTEM ARRANGEMENT DATA

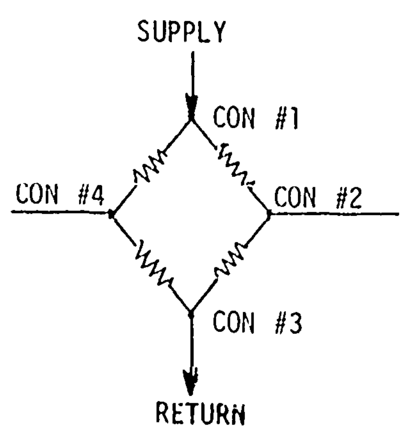
This section of the input data is used to describe the system arrangement. Having input the necessary information for all the system lines and components, one must now input the way in which these components and lines are interconnected.

Special Cases

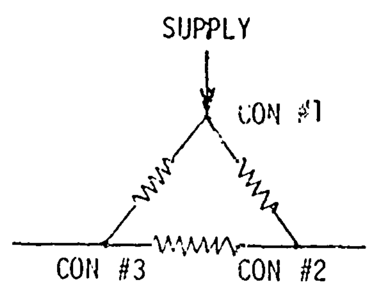
If a leg is terminated by a constant pressure source, the constant pressure has to be input along with the leg connection information via a type of reservoir. A current restriction requires that only nodes with a single leg can have a constant pressure termination. A second restriction is that there must be at least one variable node. Nodes should not be placed in the center of any component having a pressure loss since each leg connected to the node will include the pressure drop of the component.

Other component restrictions are as follows:

VALVES - TVALV22 can require three or four nodes depending upon the valve usage. The four-way valve and three-way versions of TVALV22 are described as follows:



FOUR-WAY



THREE-WAY

FOUR WAY

THREE WAY

The valve schematic should be established for steady state operation including any interflow patns. A node is then required at every connection that splits or merges flow (including interflow leakage) and at any connection that terminates flow.

Actuators - Unbalanced actuators must include a node which is used to account for any flow gain or loss in event the actuator is in motion during steady state conditions.

Reservoirs -

- RSVR61 requires one node
- RSVR62 requires two nodes open ended (not connected by a leg). One node is considered to be on the low pressure side with the other node considered on the high pressure side.

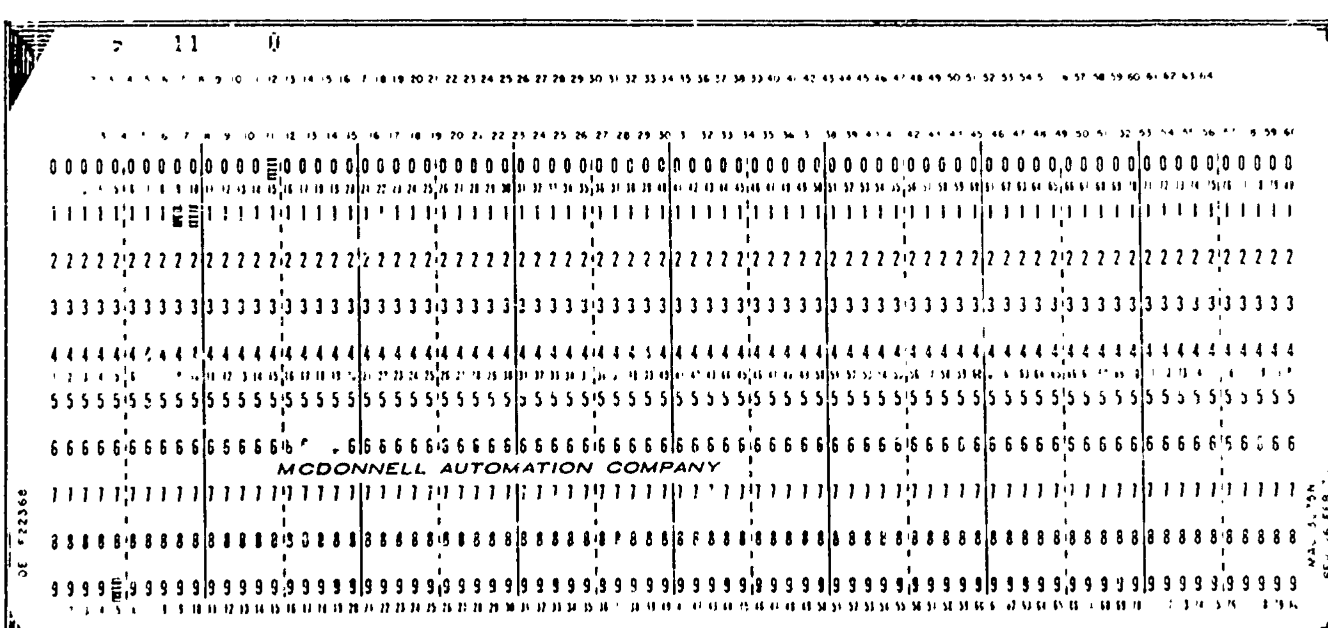
7.1 GENERAL DATA

On this card input the number of nodes and the number of legs.

CARD NUMBER 1

COLUMN	FORMAT	DATA
1-5	I5	Number of Nodes
6-10	I5	Number of Legs
11-15	I5	
16-20	I5	
21-25	I5	
26-30	I5	
31-35	I5	
36-40	I5	
41-45	I5	
46-50	I5	
51-55	I5	
56-60	I5	
61-65	I5	
66-70	I5	
71-75	I5	
76-80	I5	

EXAMPLE CARD



7.2 LEG INPUT DATA

Two or more cards are required to input the data for each leg. The first card contains the leg number, upstream node number, downstream node number, number of elements in the leg, initial flow guess, constant pressure at upstream node if applicable and constant pressure at downstream node, if applicable.

The second card or cards contains the leg connection details. Starting with the component or line at the upstream node and progressing along the flow path to the downstream node, the element number and type are input. Because of the mixture of lines and components, the need to differentiate between the element numbering system is as follows:

<u>First Pair of Data</u>

First value	>0	Component number
	=0	Element is a line
Second value	=	*Component connection number or line number

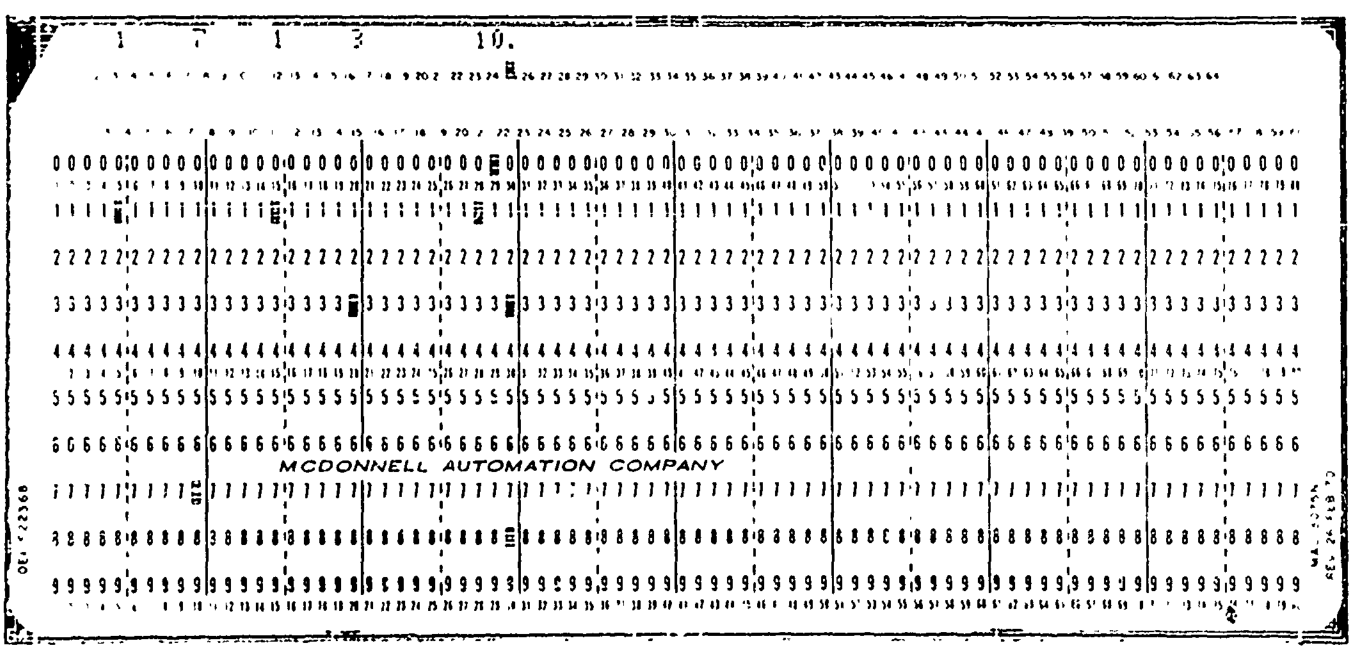
*Use upstream connection if the component has upstream and downstream connections in the same leg.

This is repeated N times for the N elements in the leg.

CARD NUMBER 1

COLUMN	FORMAT	DATA	DIMENSIONS
1-5	I5	Leg Number	--
6-10	I5	Upstream Node Number	--
11-15	I5	Downstream Node Number	--
16-20	I5	Number of Elements in Leg	--
21-30	E10.0	Initial Flow Guess	cis
31-40	E10.0	Constant Pressure at Upstream Node	psi
41-50	E10.0	Constant Pressure at Downstream Node	psi
51-60	E10.0		

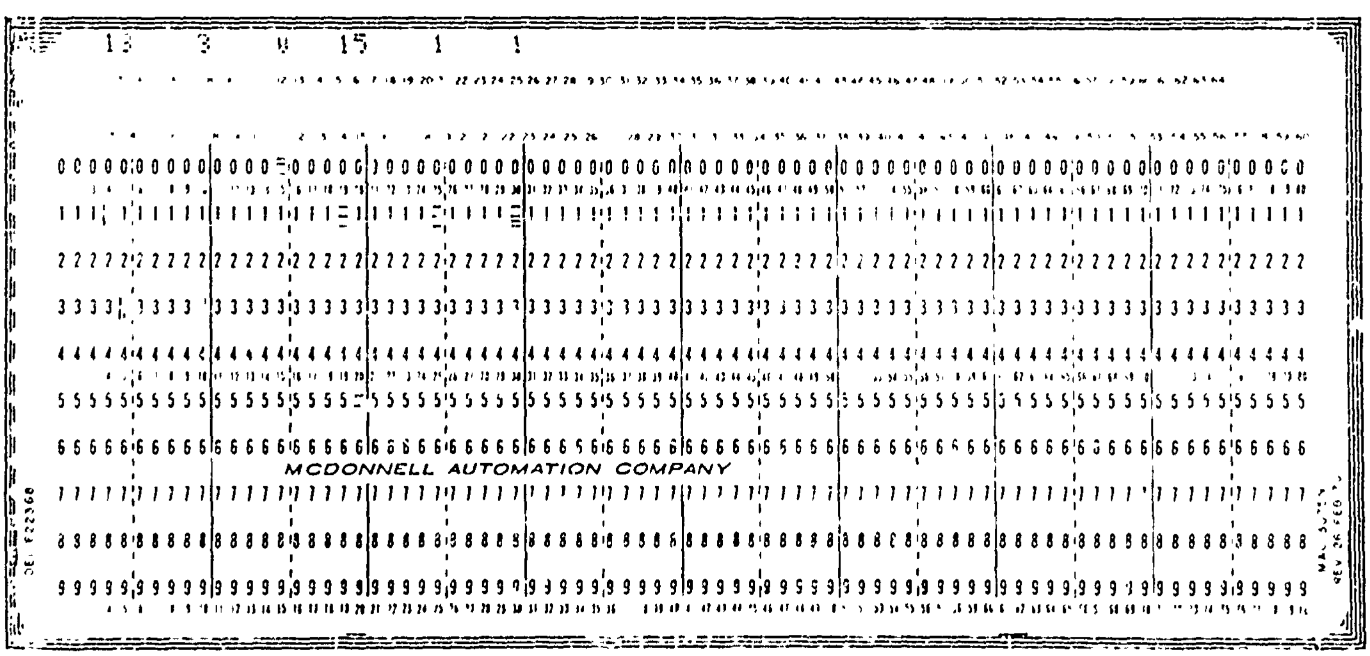
EXAMPLE CARD



CARD NUMBER 2

COLUMN	FORMAT	DATA
1-5	I5	Component Number or Zero if Line
6-10	I5	Connection or Line Number
11-15	I5	Repeat in Pairs for
16-20	I5	the Number of Elements
21-25	I5	in a Leg - Use as Many
26-30	I5	Cards as Necessary
31-35	I5	
36-40	I5	
41-45	I5	
46-50	I5	
51-55	I5	
56-60	I5	
61-65	I5	
66-70	I5	
71-75	I5	
76-80	I5	

EXAMPLE CARD



8.0 OUTPUT REQUIREMENTS DATA

The program will output in a print plot form, any calculated system variable versus time. The time interval between plotted points is input on the first general control card.

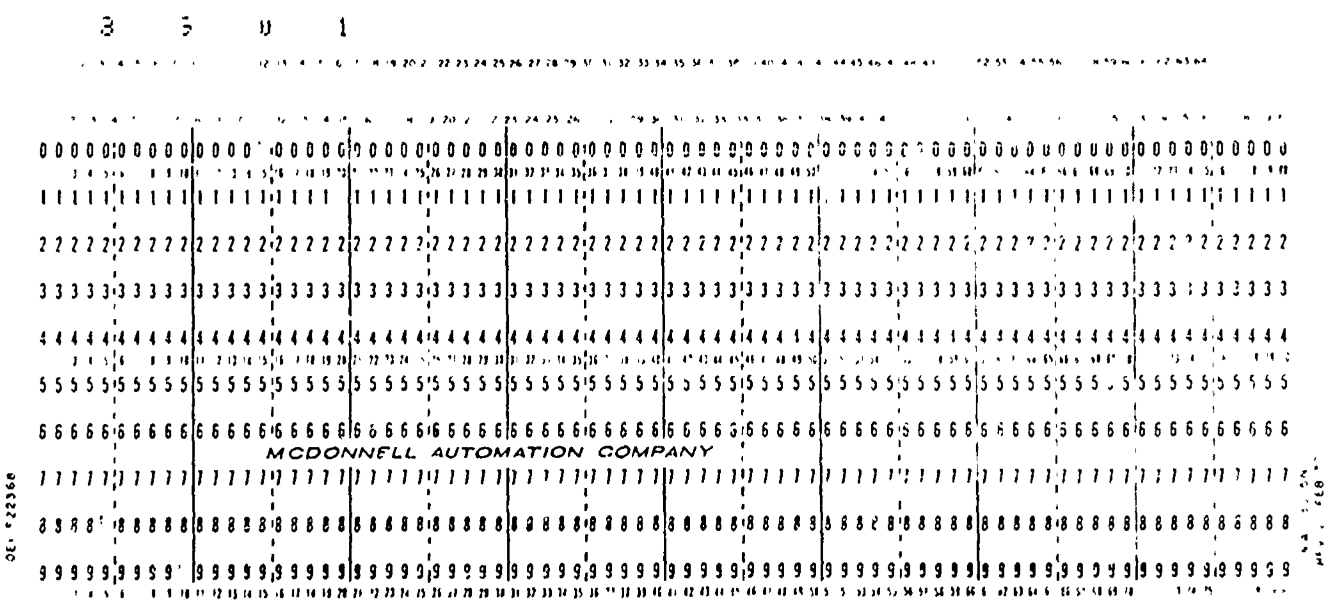
When using the print plot routine, it should be noted that 101 points are the maximum that can be plotted on one page. When more than 101 points are requested, the plot is continued on an additional page(s).

The line variables which can be selected are the pressures, flows, wall temperature, and fluid temperature up and downstream of each line. The component variables which can be selected are listed in paragraph 8.2.

PLOT DATA CARD

COLUMN	FORMAT	DATA
1-5	I5	Number of line plot data cards
6-10	I5	Number of component variables to be plotted
11-15	I5	0
16-20	I5	0 - Normal graphs +1 - Prints listing of plotted values
21-25	I5	0
26-30	I5	0
31-35	I5	0 - No Graphs
		+1 - Normal Graphs
36-40	I5	0 - Normal Graphs
		+1 - Prints Magnitudes (*)

EXAMPLE CARD



8.1 OUTPUT OF LINE VARIABLES

Line variables, pressure, flow, component temperature, fluid temperature, and wall temperature at the upstream and downstream of each line are the possible plots. A + stands for upstream and a - stands for the downstream location. Any or all may be plotted for each line on the line Plot Card, and they may appear in any order.

1 - pressure

2 - flow

3 - component temperature

4 - fluid temperature

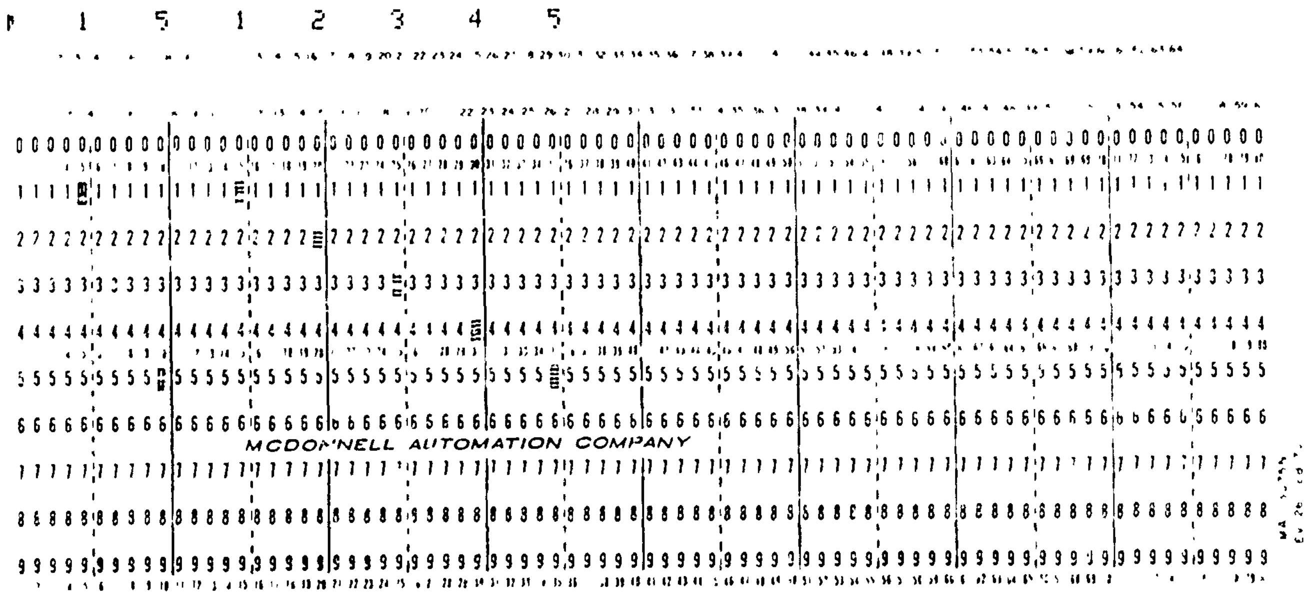
5 - wall temperature

The number of plots (total, up to 10) must be included in columns 6-10.

LINE PLOT CARD

COLUMN	FORMAT	DATA
1-5	I5	Line Number to be Plotted
6-10	I5	Number of Plots for that Line
11-15	I5	+1 - Provides upstream pressure
16-20	I5	-1 - Provides downstream pressure
21-25	I5	+2 - Provides upstream flow
26-30	I5	-2 - Provides downstream flow
31-35	I5	+3 - Provides upstream component temperature
36-40	I5	-3 - Provides downstream component temperature
41-45	I5	+4 - Provides upstream fluid temperature
46-50	I5	-4 - Provides downstream fluid temperature
51-55	I5	+5 - Provides upstream wall temperature
56-60	I5	-5 - Provides downstream wall temperatu
61-65	I5	
66-70	I5	
71-75	I5	
76-80	I5	

EXAMPLE CARD



8.2 OUTPUT OF COMPONENT VARIABLES

The component variables to be output are selected from Tables 8.2-21 - 8.2-102.

The total number of component variables to be plotted must be input on the Plot data Card in columns 6-10 and should equal the number of pairs of data on the following cards.

COMPONENT PLOT CARD

COLUMN	FORMAT	DATA
1-5	I5	Component Number Assigned
6-10	I5	Variable Number to be Plotted
11-15	I5	(This is repeated using additional cards, if necessary,
16-20	I5	until all component variables to be plotted have been
21-25	I5	listed.)
26-30	I5	
31-35	I5	
36-40	I5	
41-45	I5	
46-50	I5	
51-55	I5	
56-60	I5	
61-65	I5	
66-70	I5	
71-75	I5	
76-80	I5	

EXAMPLE CARD

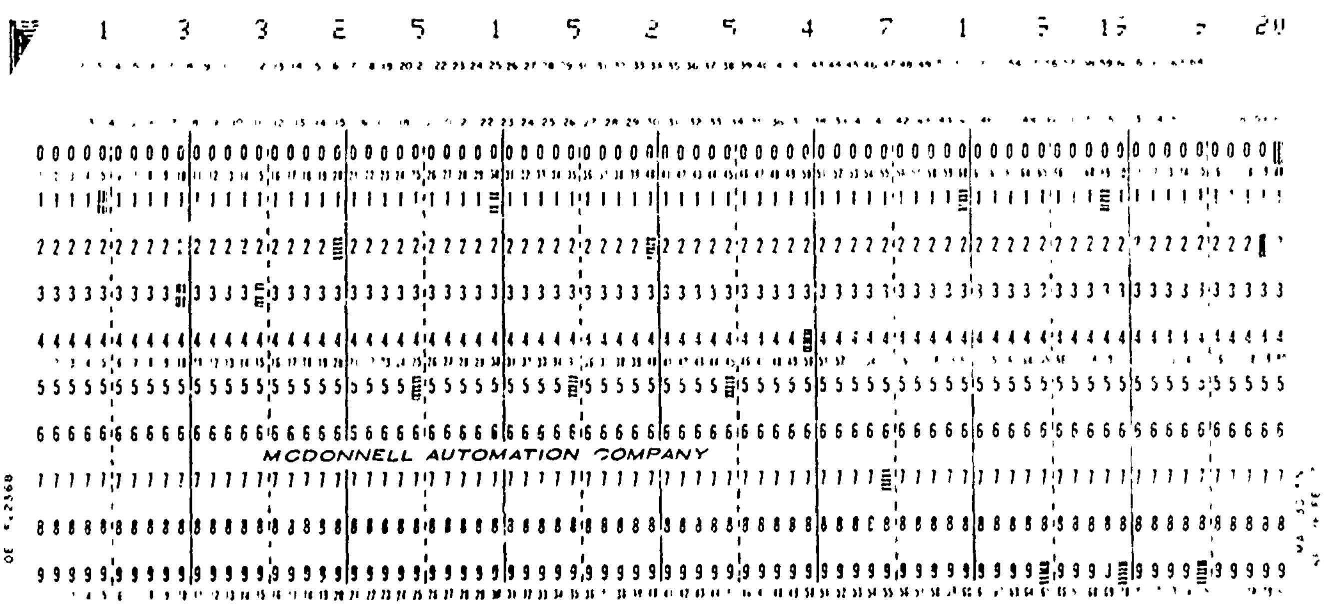


TABLE 8.2-21

TVALV21

PROGRAMMED VARIABLE SELECTION

Number	Name	Description	Dimension
3	TVP	Temperature of the Valve Piston	°F

TABLE 8.2-31

TCVAL31

PROGRAMMED VARIABLE SELECTION

Number	Name	Description	Dimension
9	TP	Temperature of the Poppet	°F

TABLE 8.2-62

TRSVR62

PROGRAMMED VARIABLE SELECTION

Number	Name	Description	Dimension
7	TP	Temperature of the Reservoir Piston	°F
8	ASFR	Surface Area Fluid to Reservoir Walls	$in.^2$
9	VOLUME	Volume of the fluid in the Reservoir	$in.^3$

TABLE 8.2-71

TACUM71

PROGRAMMED VARIABLE SELECTION

Number	Name	Description	Dimension
1	TAN	Temperature of the Walls Gas Side	°F
3	TPN	Temperature of the Piston	°F
4	TG	Temperature of the Gas	°F
5	VOLO	Volume of the Oil	$IN.^3$
6	VOLG	Volume of the Gas	$IN.^3$
7	VP	Velocity of the Piston	IN./SEC.
9	PO	Pressure of the Oil	PSI
10	PG	Pressure of the Gas	PSI

TABLE 8.2-69

THEX69

PROGRAMMED VARIABLE SELECTION

Number	Name	Description	Dimension
3	TEC	Temperature of the Exchanger Cooling Liquid	°F
4	TEP	Temperature of the Exchanger Pipe	°F

TABLE 8.2-102

TACT102

PROGRAMMED VARIABLE SELECTION

Number	Name	Description	Dimension
3	TPN	Temperature of the Piston	°F
4	TFA1	Temperature of the Fluid in Volume 1	°F
5	TFA2	Temperature of the Fluid in Volume 2	°F
6	P1	Pressure in Volume 1	PSI
7	P2	Pressure in Volume 2	PSI
8	X	Distance the Piston is From Zero Stroke	IN.
9	VEL	Velocity of the Piston	IN./SEC.
16	VOLUME1	Volume 1	$IN.^3$
17	VOLUME2	Volume 2	$IN.^3$

TABLE 8.2-51

TPUMP51

PROGRAMMED VARIABLE SELECTION

NUMBER	NAME	DESCRIPTION	DIMENSION
1	TFP1	Inlet Volume Fluid Temperature	°F
5	TPN	Rotating Group Temperature	°F
10	PINLET	Inlet Iressure	PSI
13	PCASE	Case Pressure	PSI
14	POUTLT	Outlet Pressure	PSI

9.0 COMPUTER OUTPUT

The time history print plots of flow, pressure, temperatures, and component state variables form the basic output of the program. By the addition of simple write statements, the output can also be written to files for storage and subsequent processing or to the output for printing. Since there are so many ways of handling the output information, each dependent on the user's local facilities, it is pointless to discuss the details of how to transfer files, etc.

The user should also beware of inputting unrealistic rates of valve opening and closure, since these can exaggerate the steady state solution.

The user will soon become aware of what problems to look for, and the experience gained in using HYTTHA will help in both the detailed analysis and the intuitive approach to solving problems.